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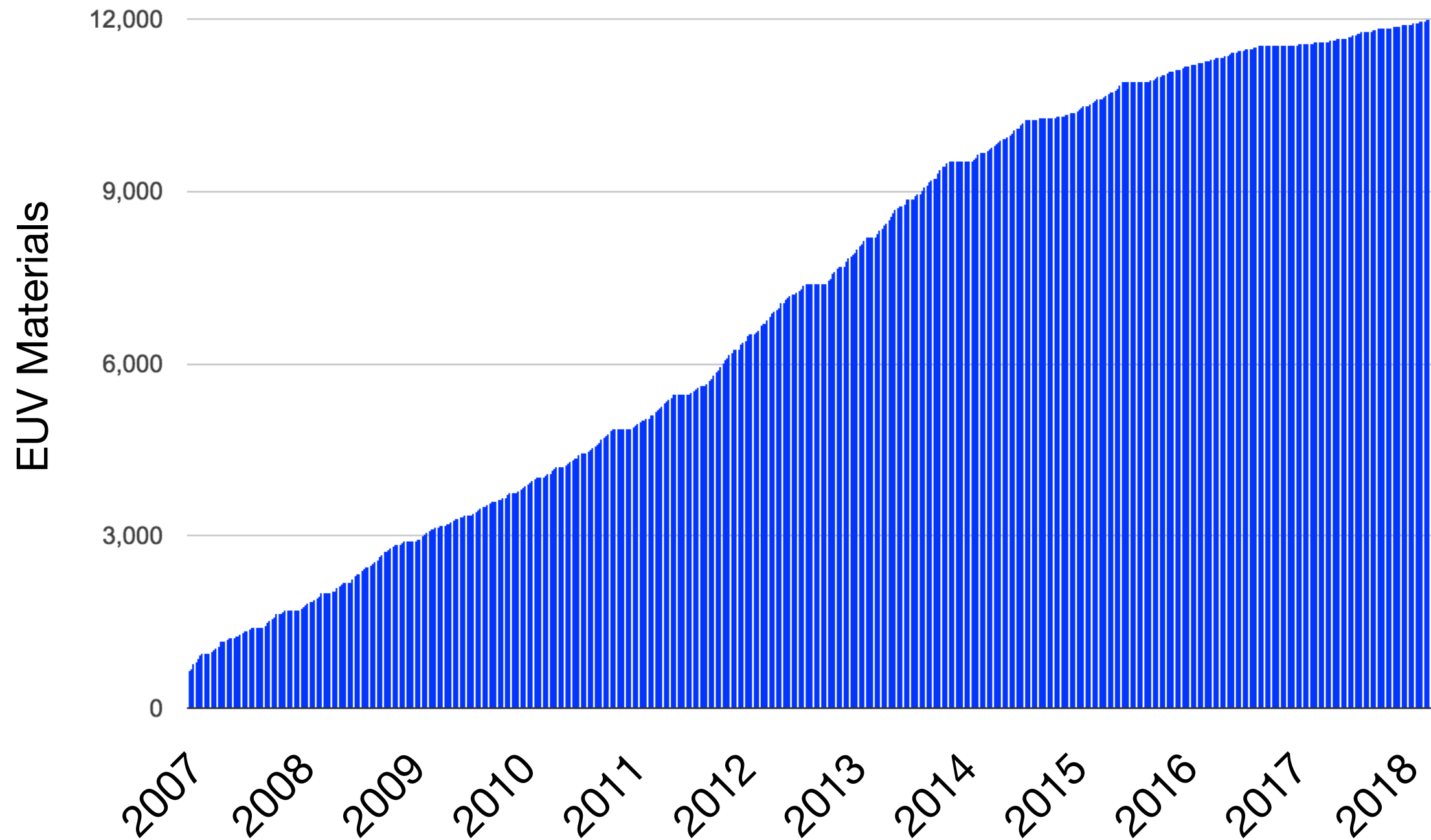
Rama Ayothi

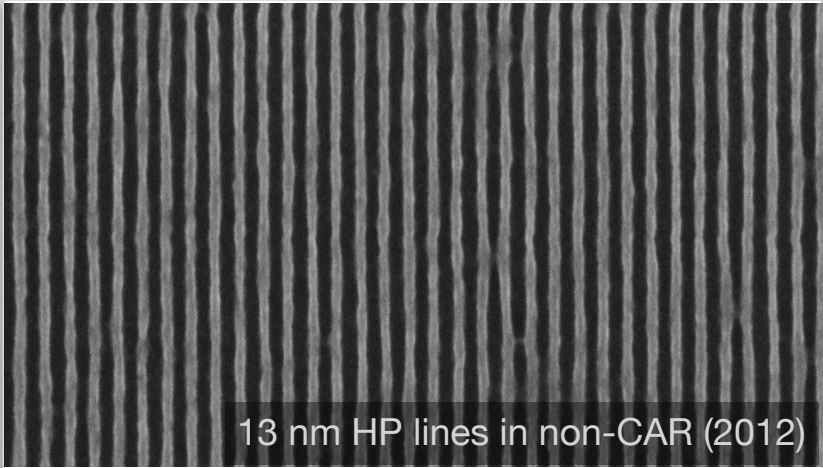
# MET5 Update

# Testing EUV Materials Since 2004



# 12000 Materials Tested





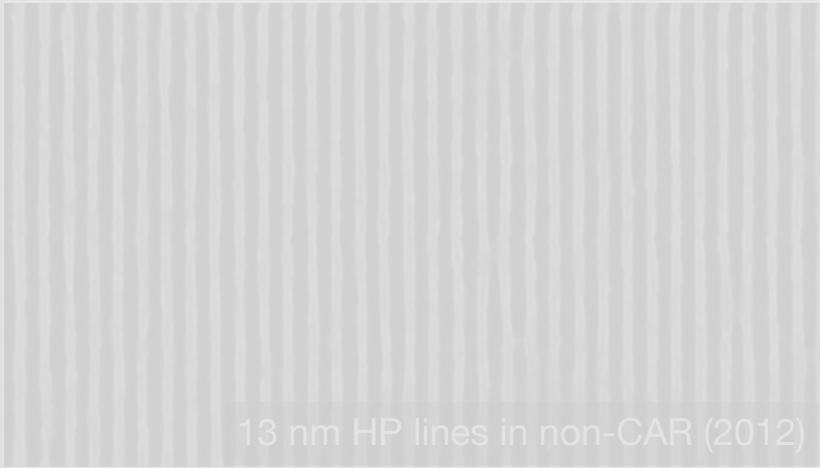
13 nm HP lines in non-CAR (2012)

# 0.3-NA Litho

2004 - Today

Resolution	13 nm
Throughput	1.5 WPH @ 30 mJ/cm <sup>2</sup> 8x8 FEM
Field Size	600 um x 200 um
Process Control	Manual processing
Wafer Size	100 mm
Materials Tested	11994

60% of tool time is with new resists



13 nm HP lines in non-CAR (2012)

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Field Size	600 um x 200 um
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Materials Tested	11994

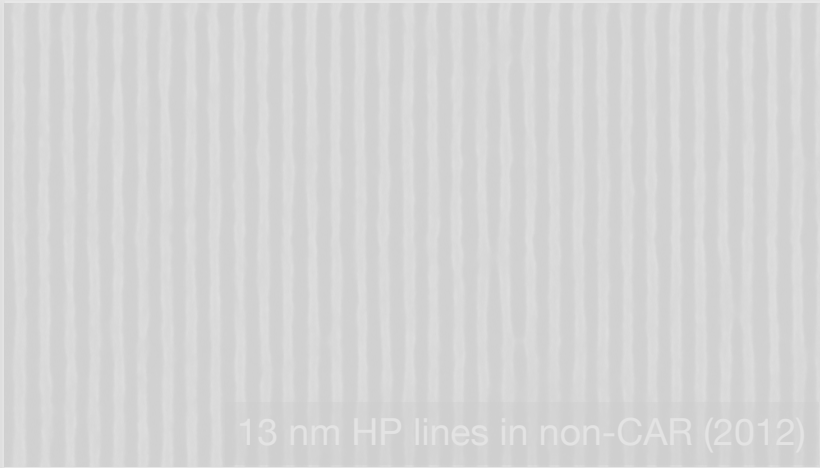
60% of tool time is with new resists



# Clear Field Exposures

2010 - Today

Apertures	1 cm x 1 cm sq. 500 um Ø
Throughput	7 WPH @ 7 mJ/cm <sup>2</sup> 50 shot curve
Intensity Variation	1.8% RMS
Wafer Size	100 mm
Materials Tested	5721



13 nm HP lines in non-CAR (2012)

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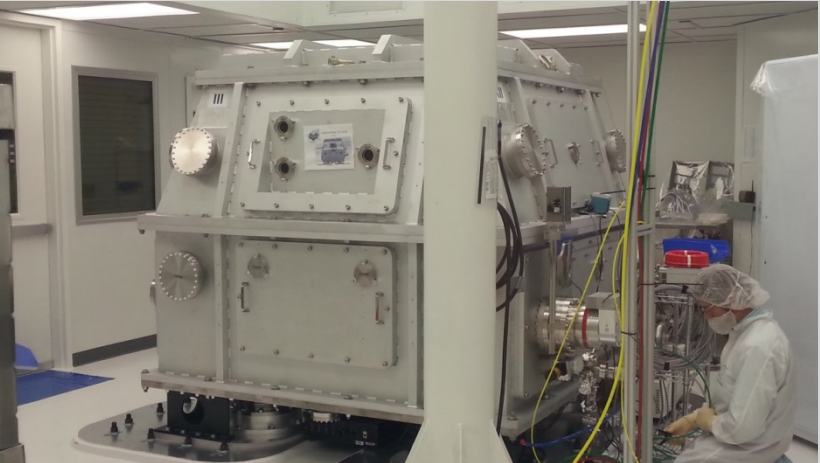
60% of tool time is with new resists



# Clear Field Exposures

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Apertures	1 cm x 1 cm sq. 500 um Ø
Throughput	7 WPH @ 7 mJ/cm <sup>2</sup> 50 shot curve
Intensity Variation	1.8% RMS
Wafer Size	100 mm
Materials Tested	5721



# 0.5-NA Litho

Commissioning In Progress

Resolution	8 nm
Throughput	2-3 WPH @ 200 mJ/cm <sup>2</sup> 8x8 FEM
Field Size	200 um x 30 um
Process Control	Robotic sample processing and exchange. Tailored for research
Wafer Size	200 mm

**0.5-NA Litho**

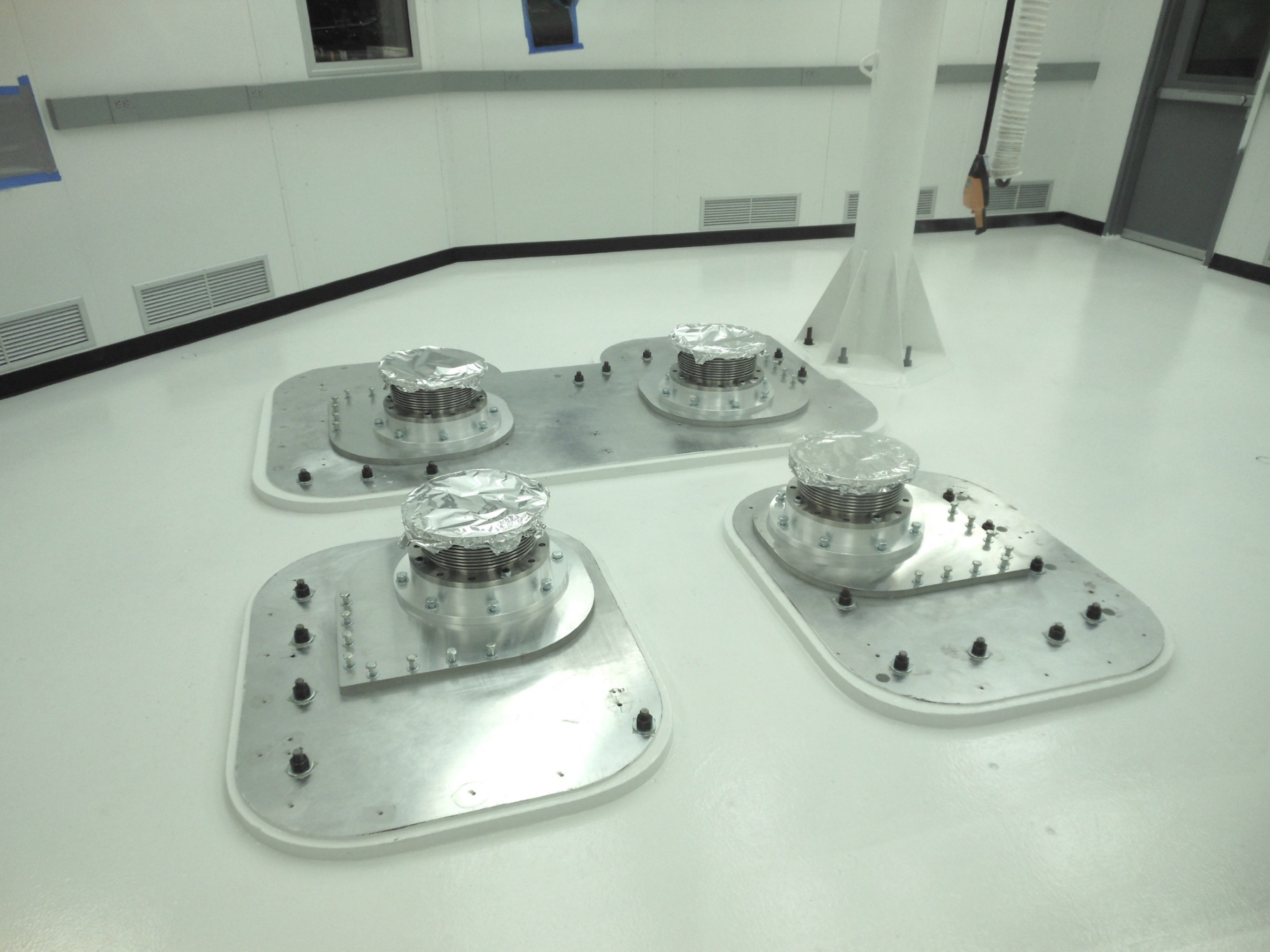




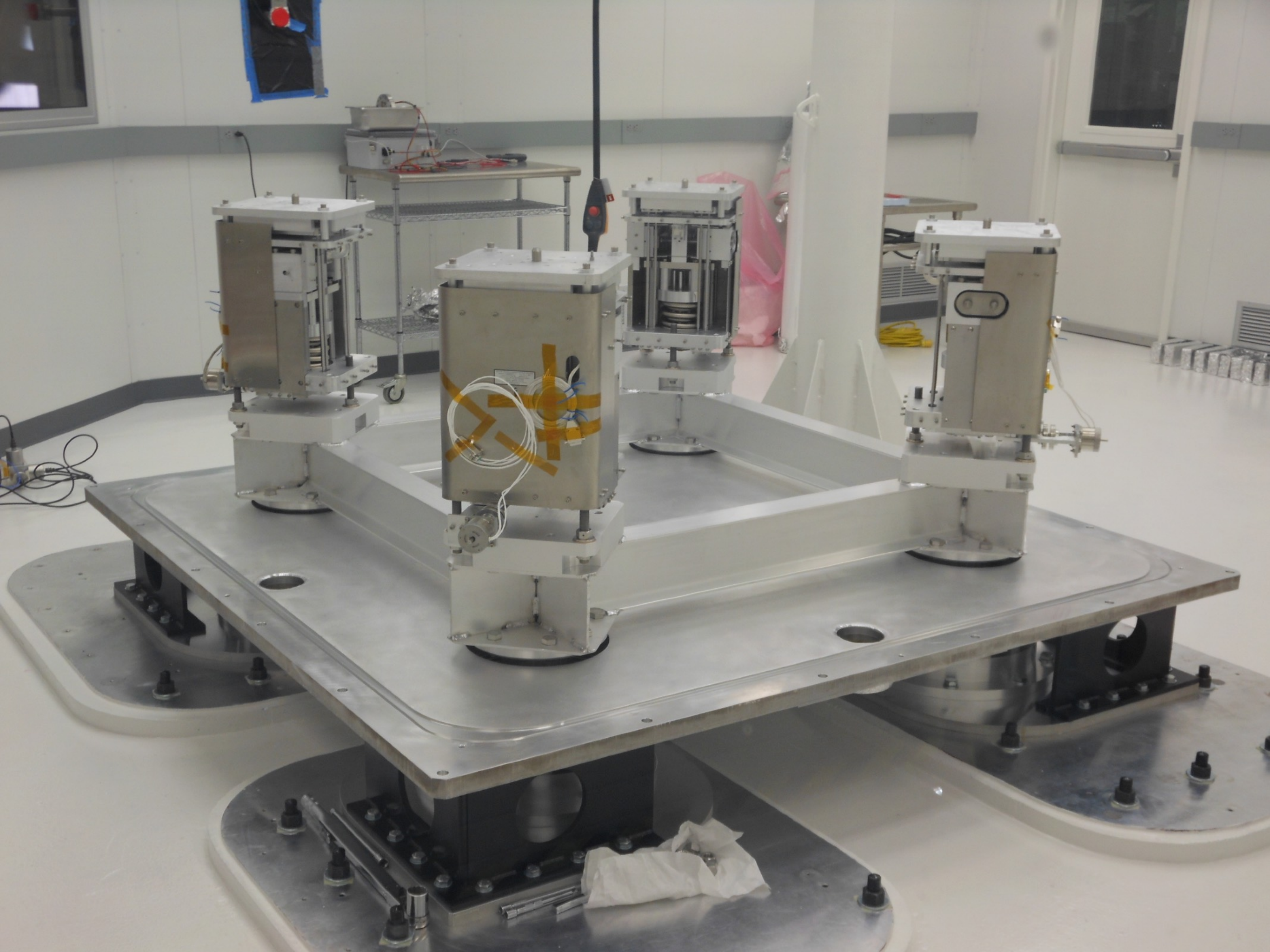
















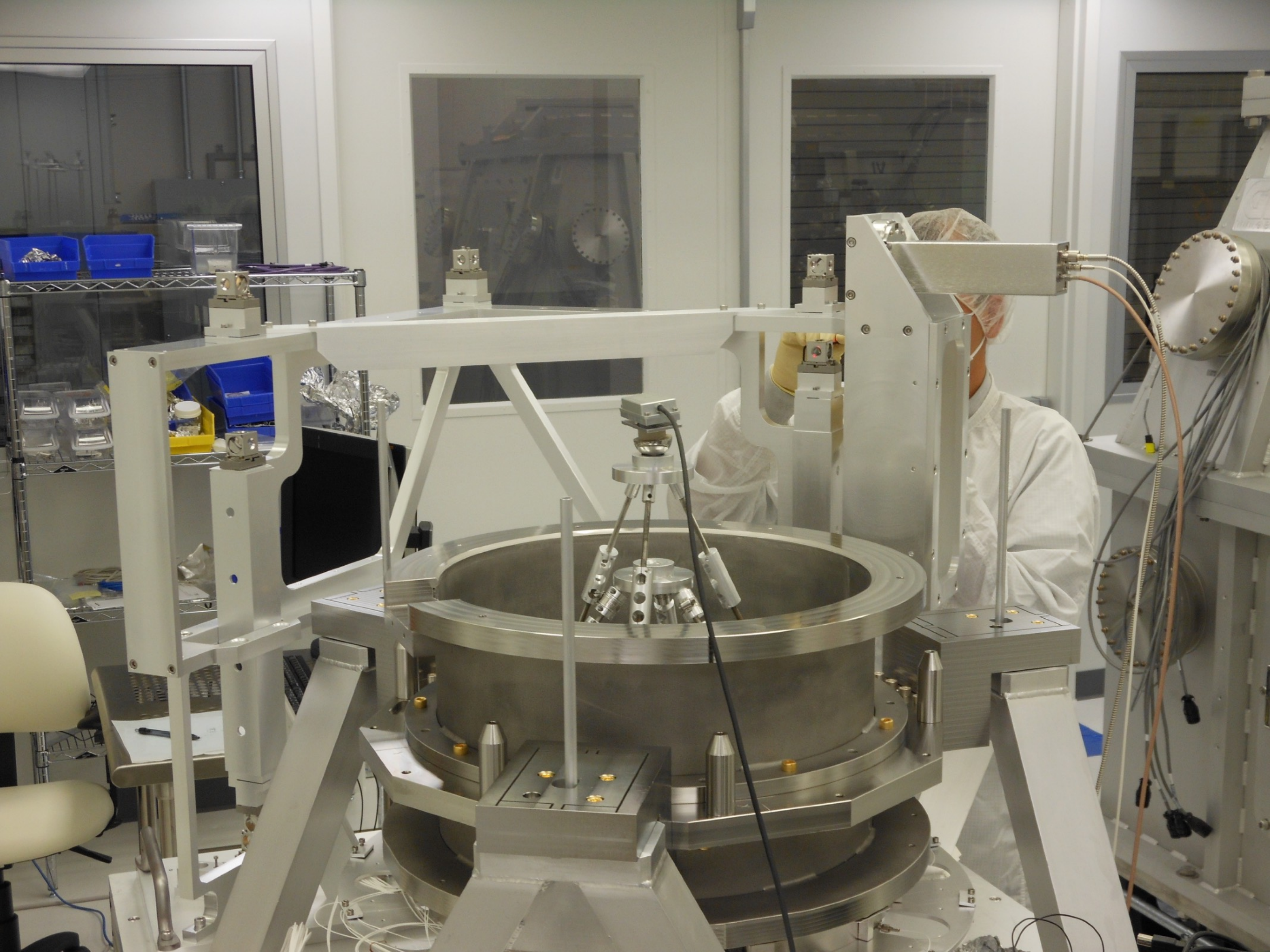








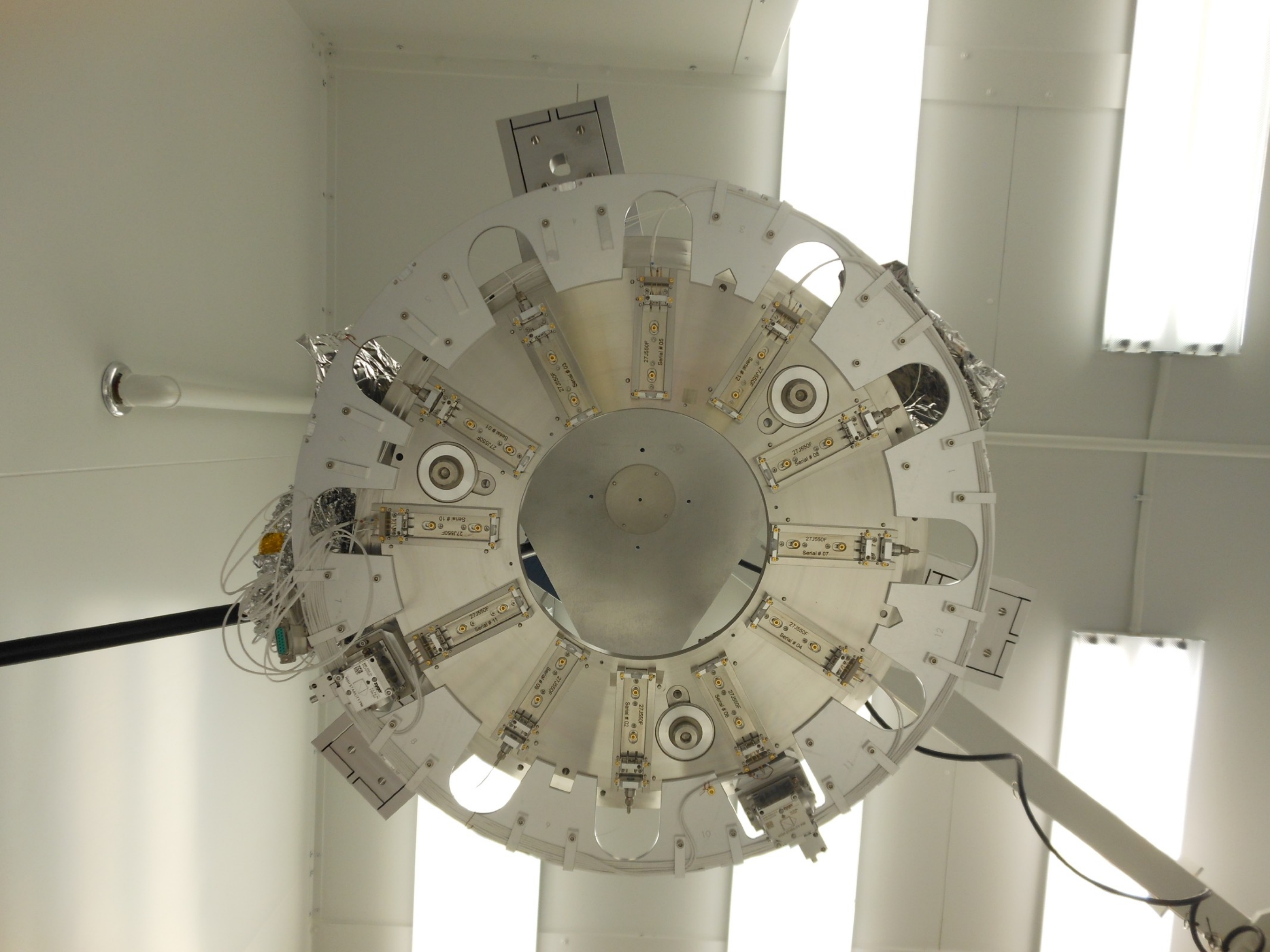
















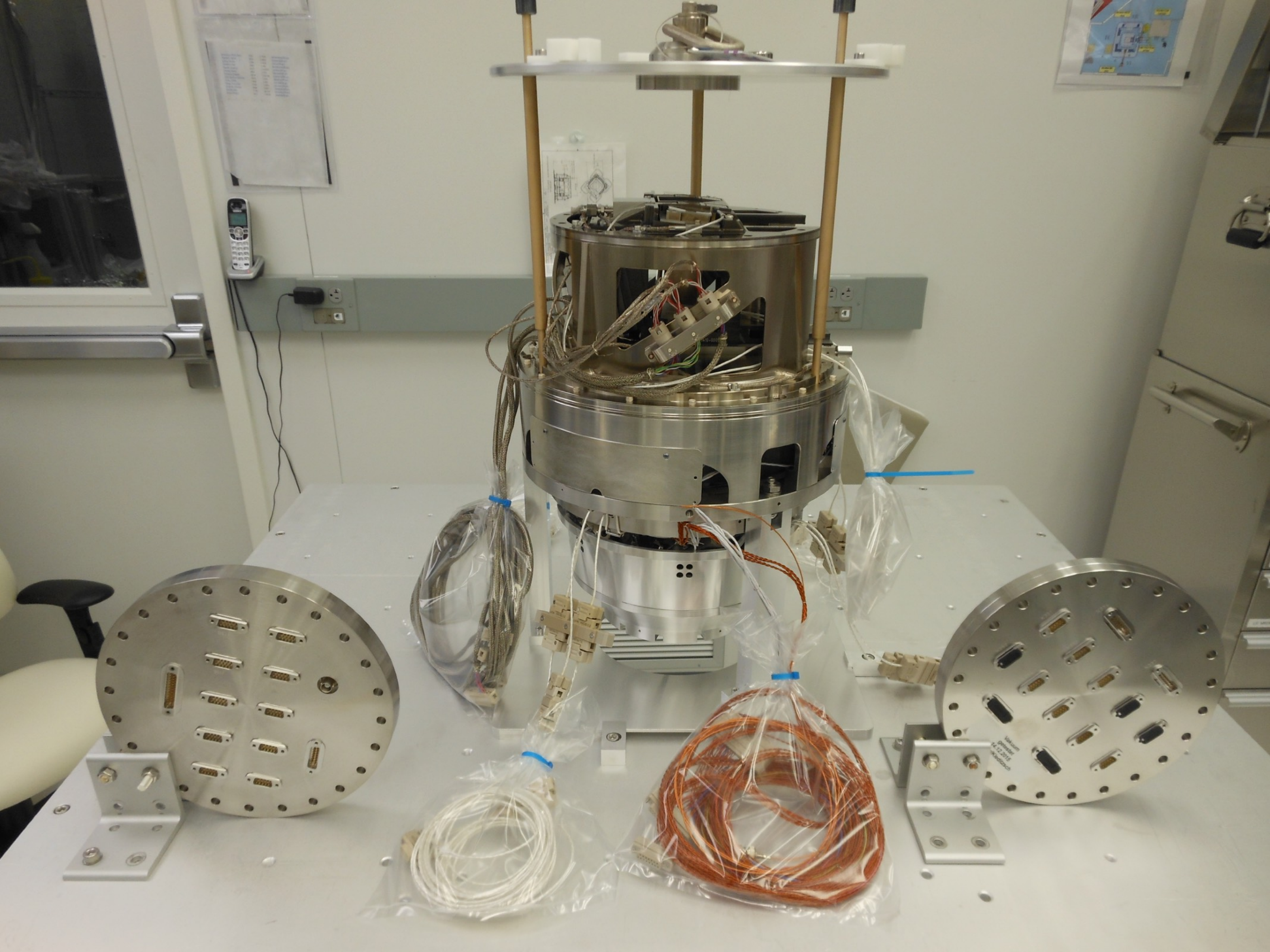




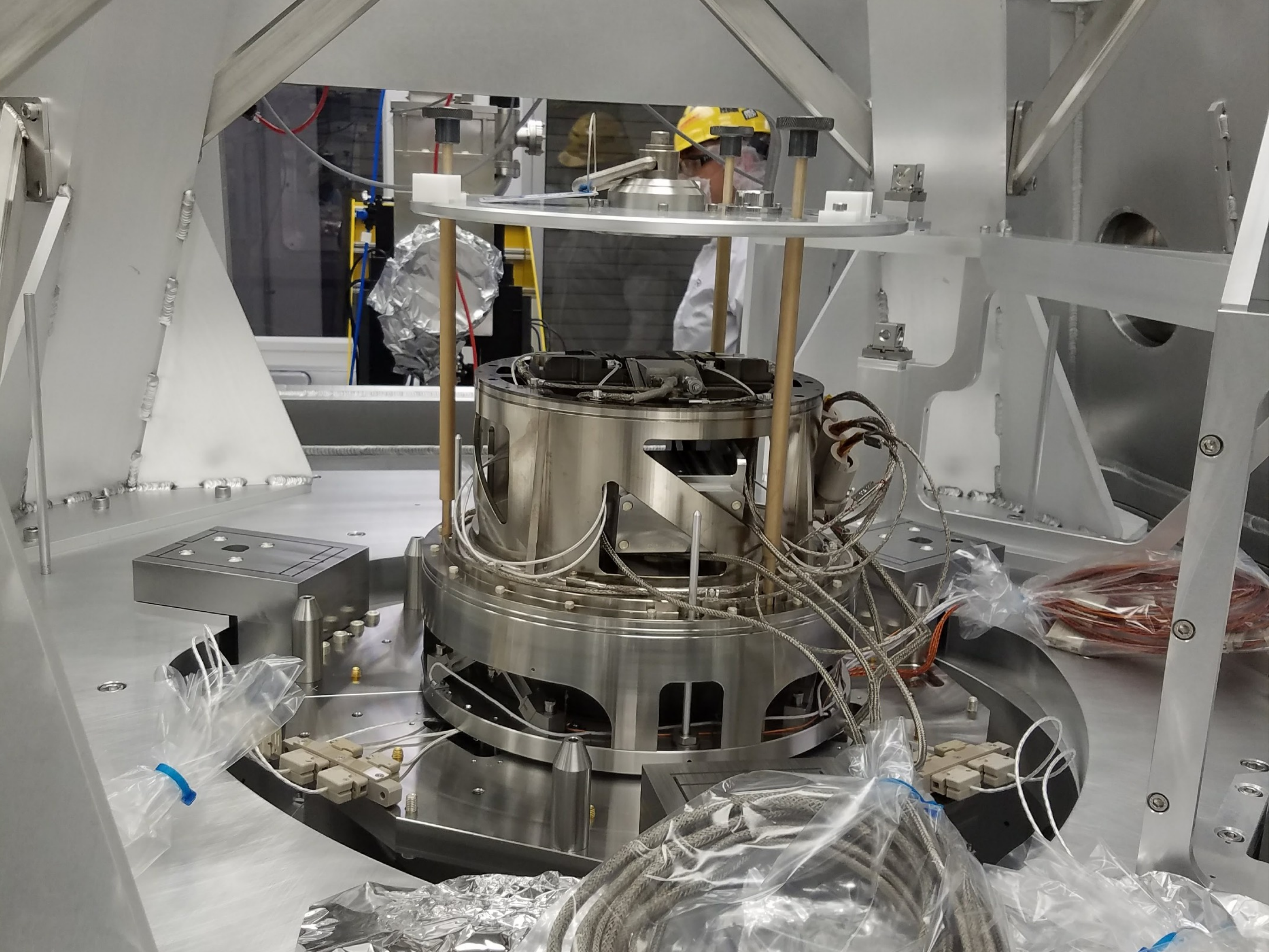














# Commissioning

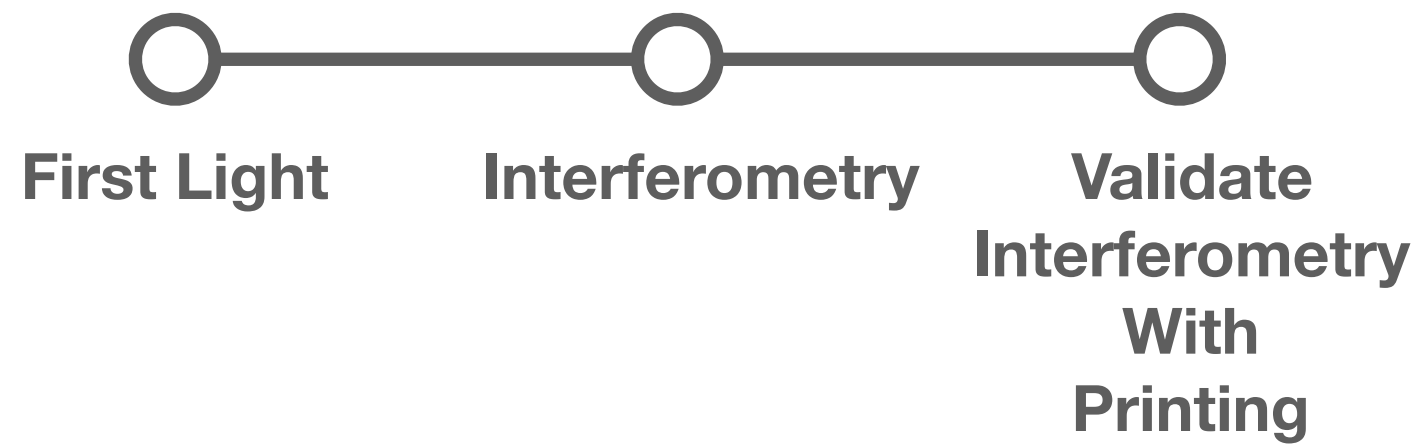


**First Light**

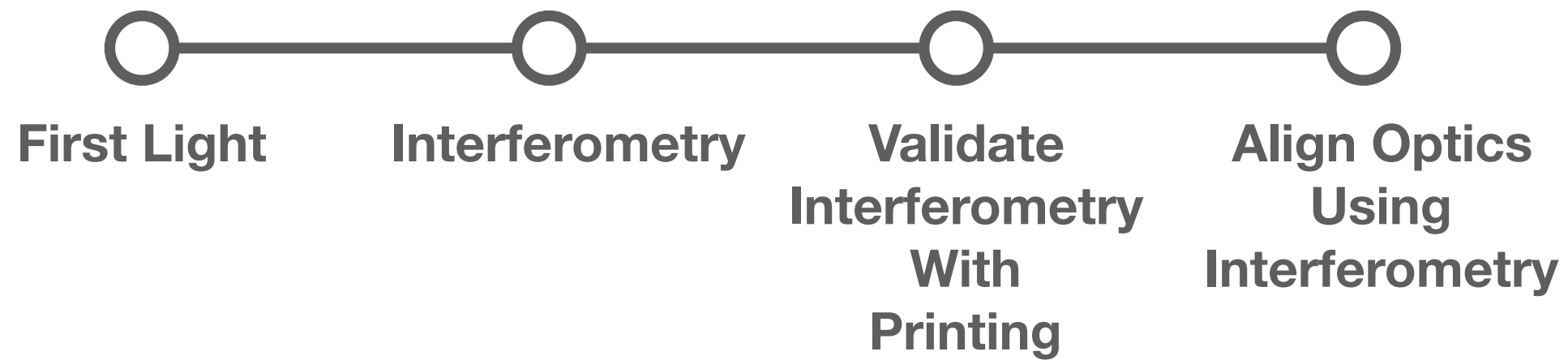


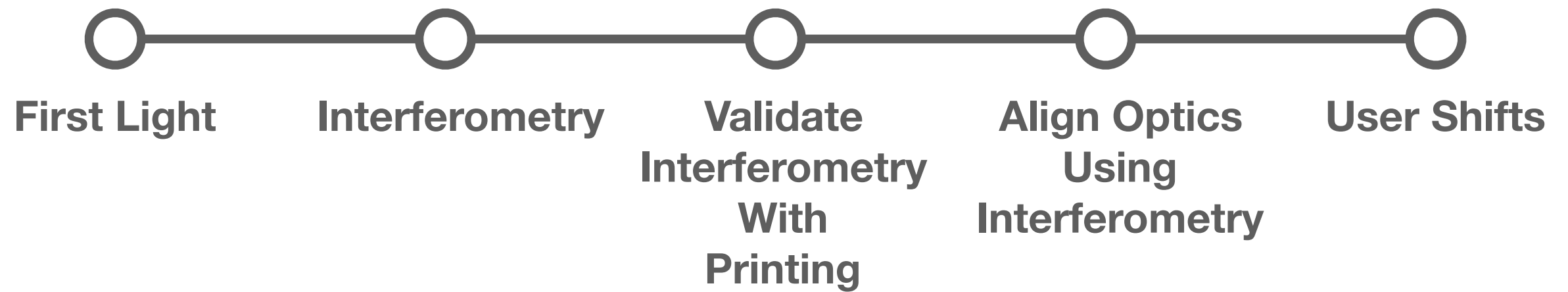
**First Light**

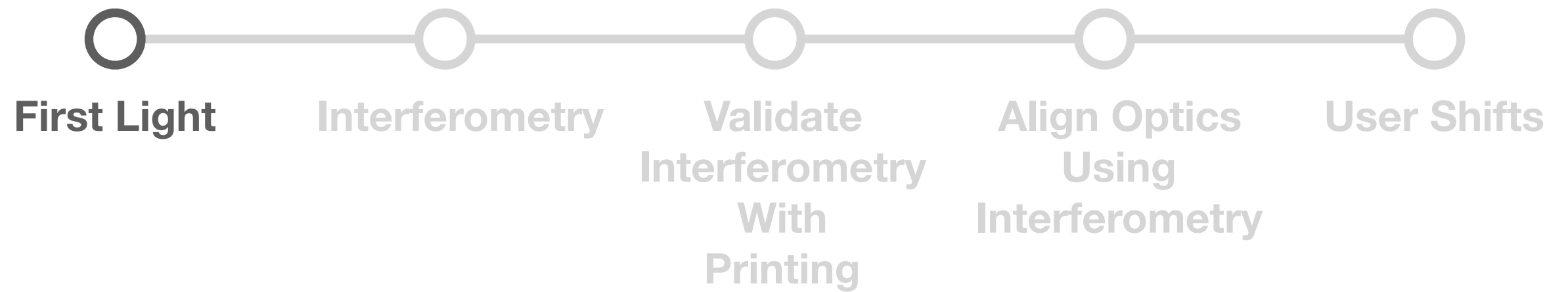
**Interferometry**



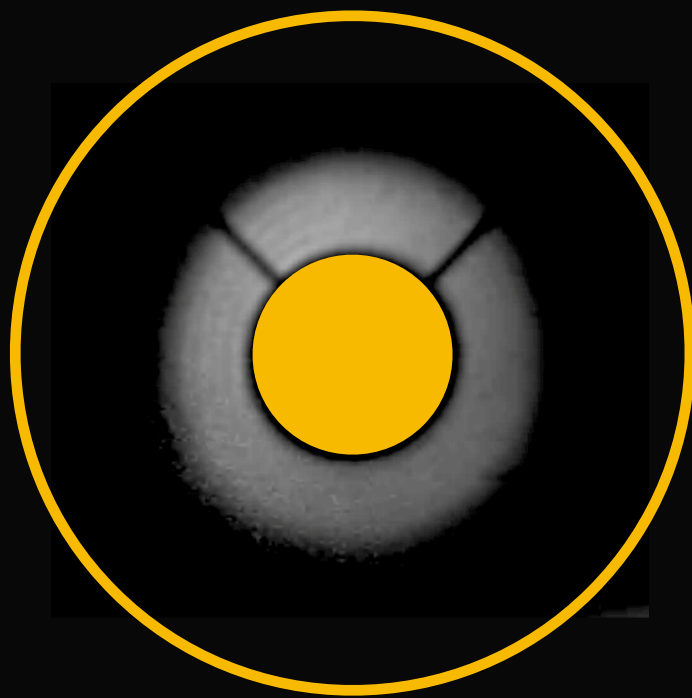
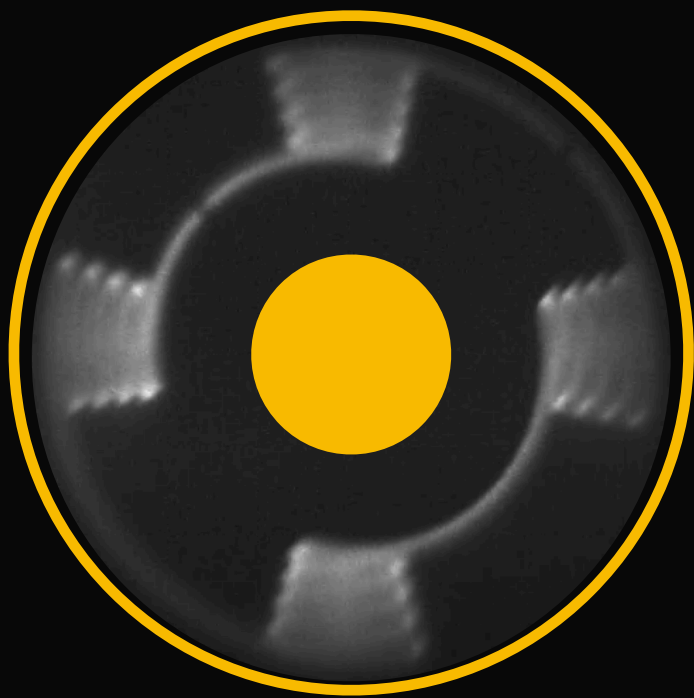


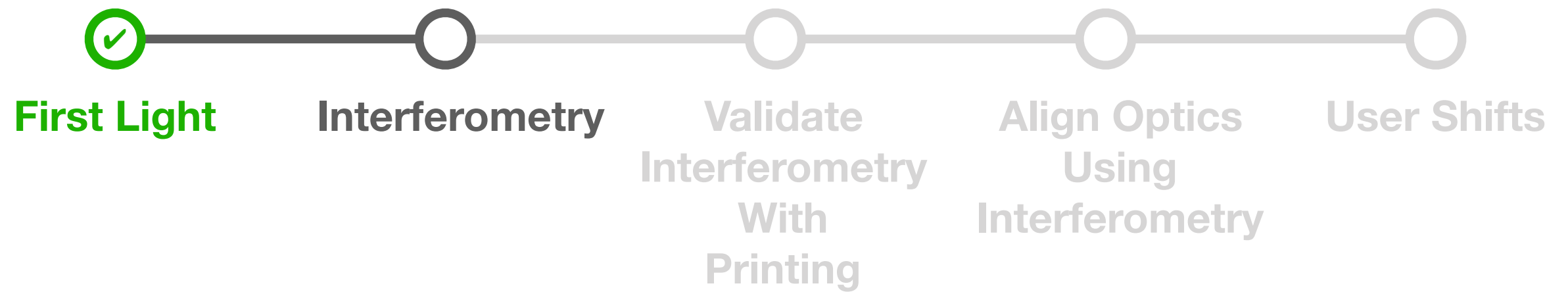


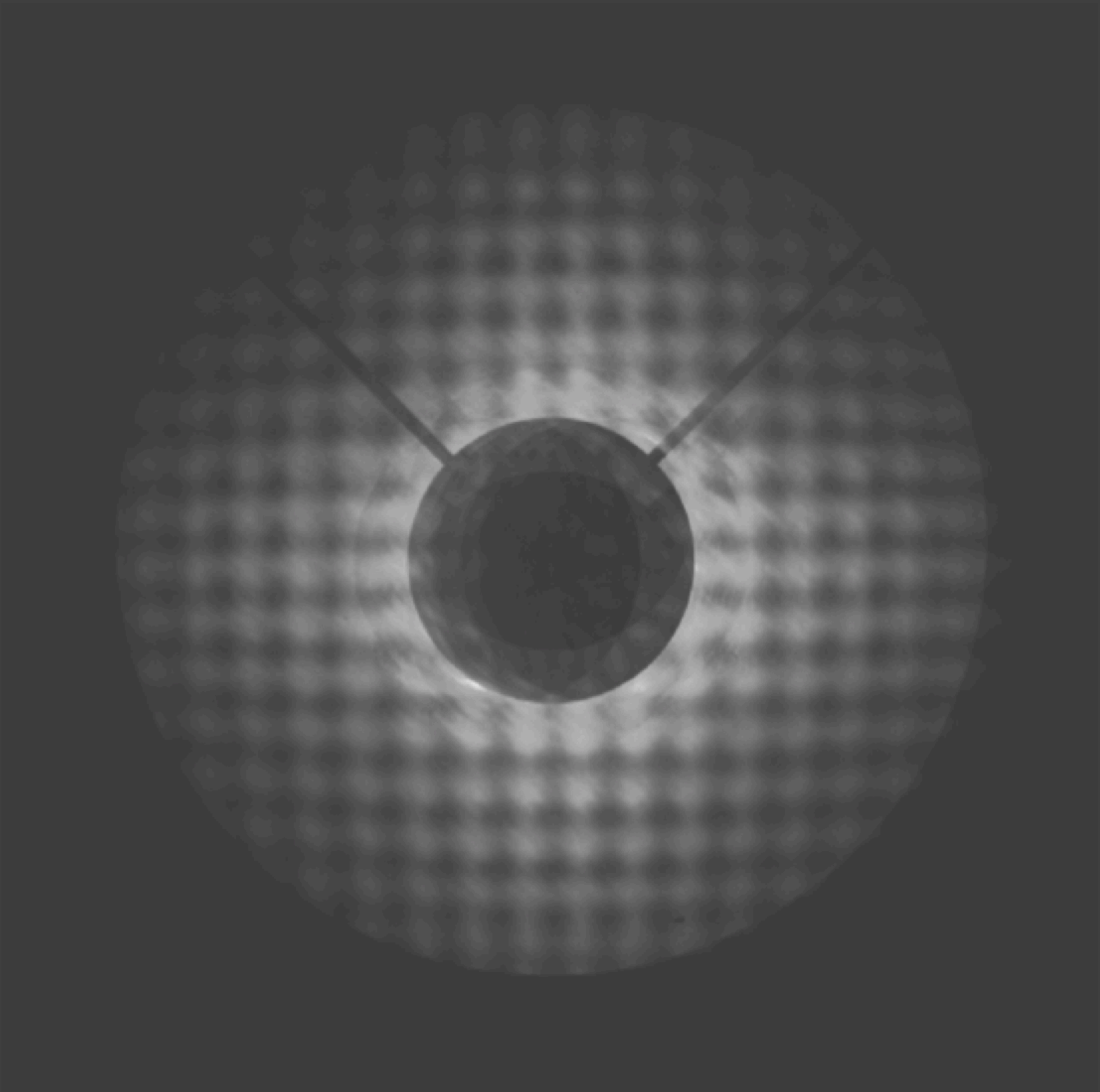




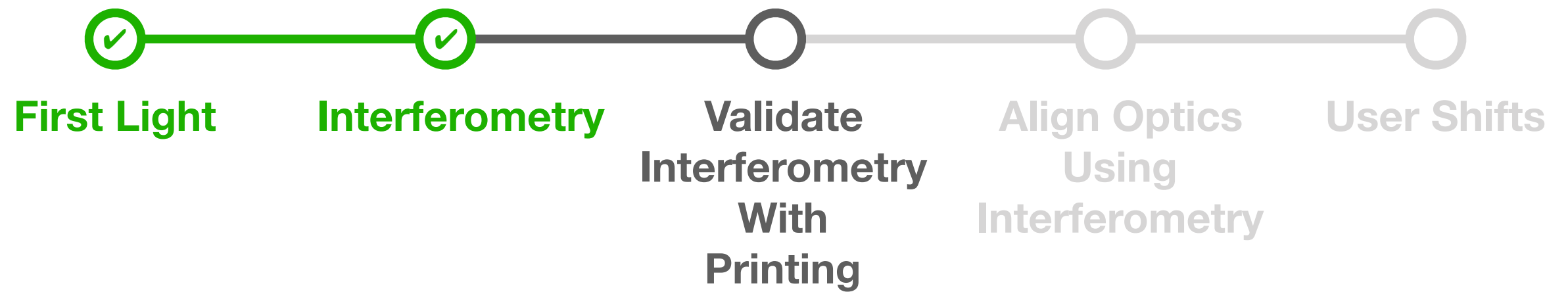
# Pupil Fill

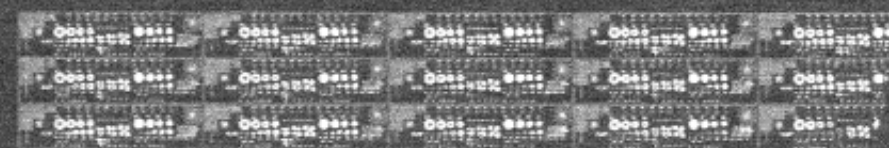
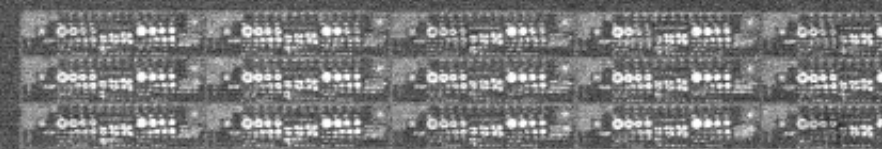
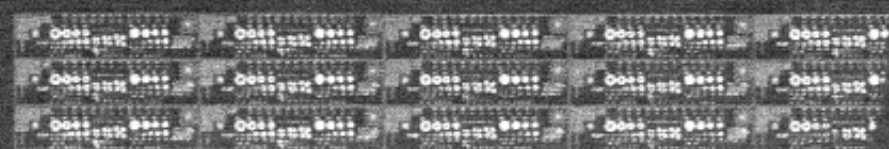




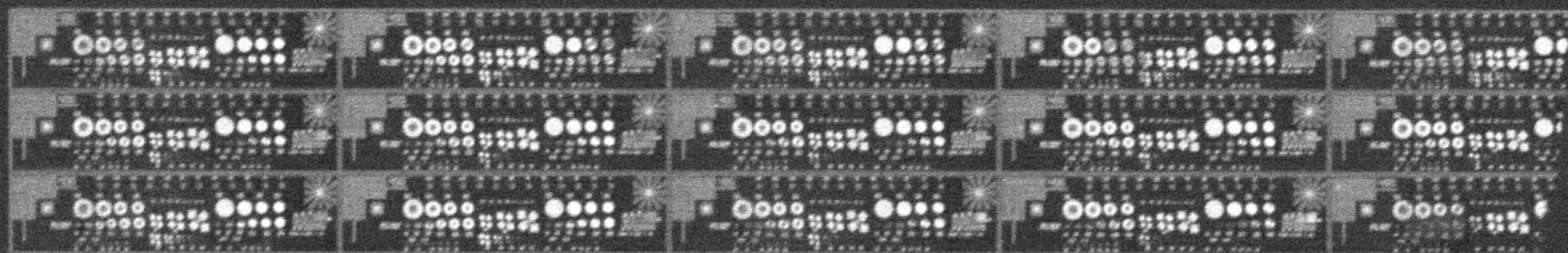


**Presented by Ryan Miyakawa**





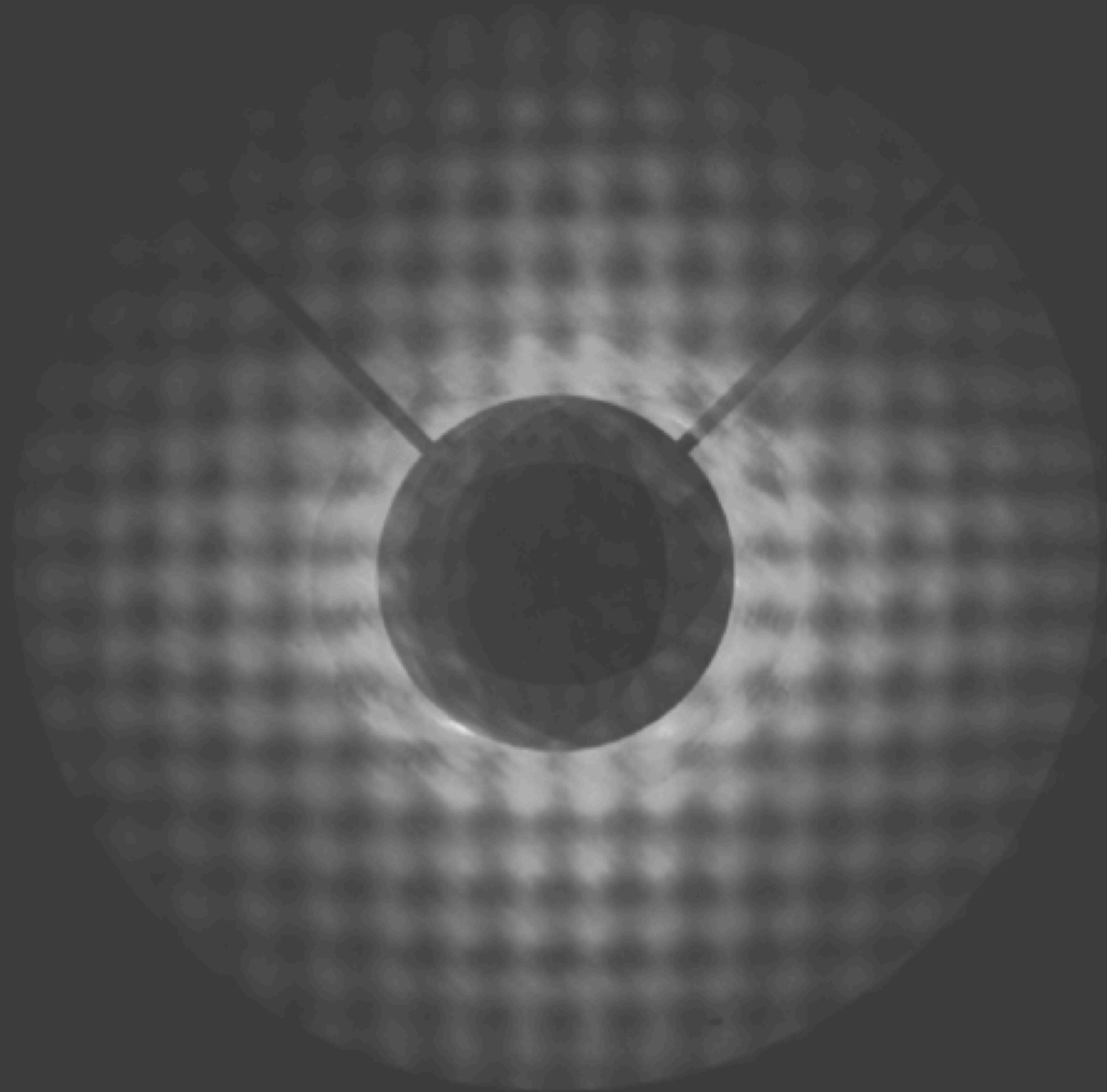




S4800 2.0kV 3.0mm x600 SE(M)

50.0um

# Interferometry on MET5



Presented by Ryan Miyakawa

$$d_{\text{min}} \geq k_1 \frac{\lambda}{NA}$$

$$d_{\text{min}} = k_1 \frac{\lambda}{NA}$$

(Diffraction limited performance)

# **EUV optical aberrations**

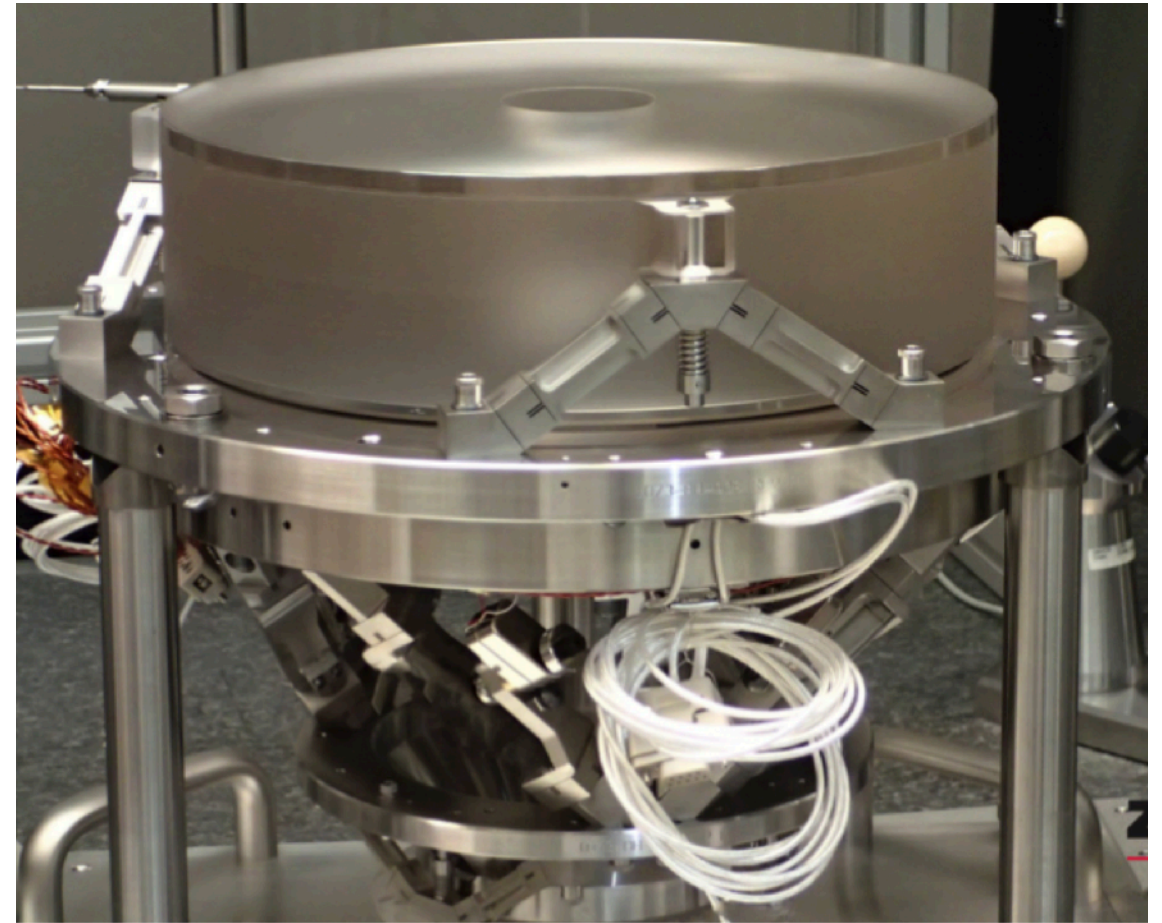
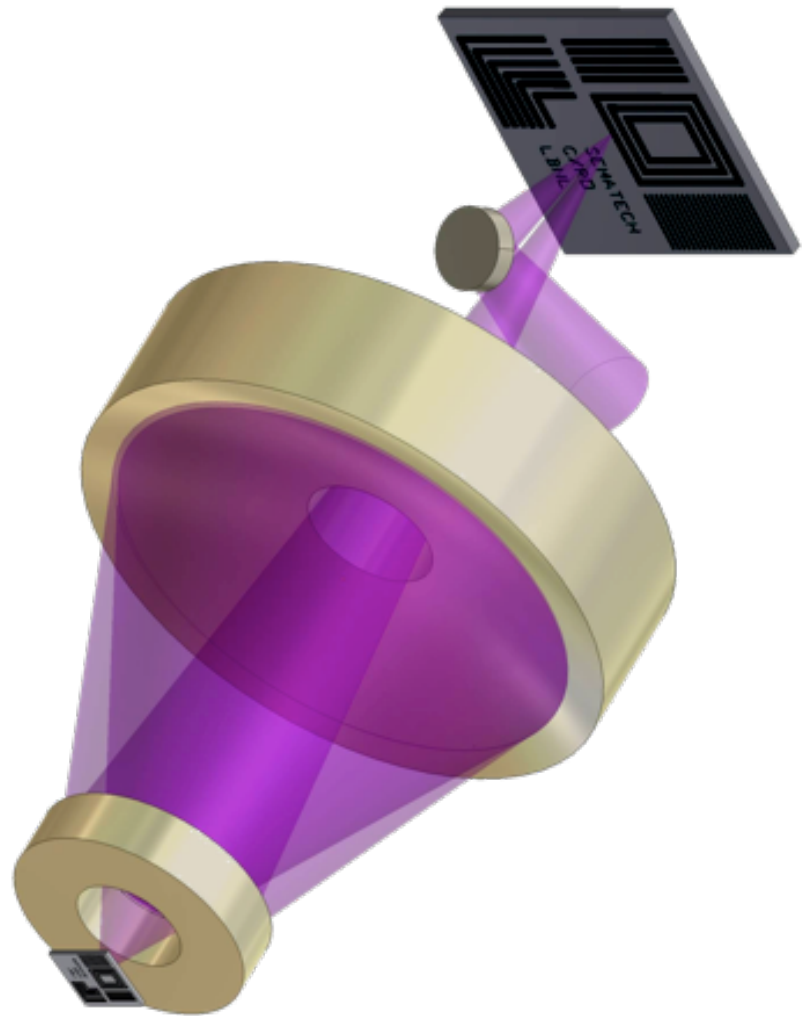
# **EUV optical aberrations**

**1. Alignable**

**2. Non-alignable**

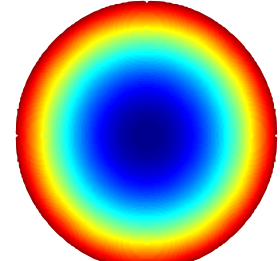
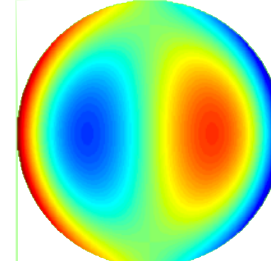
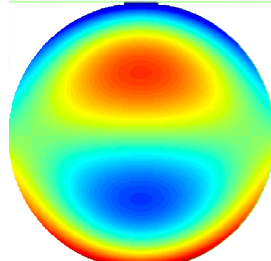
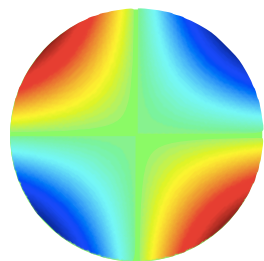
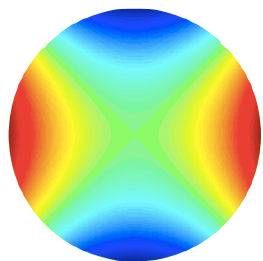


# “Alignable” aberrations

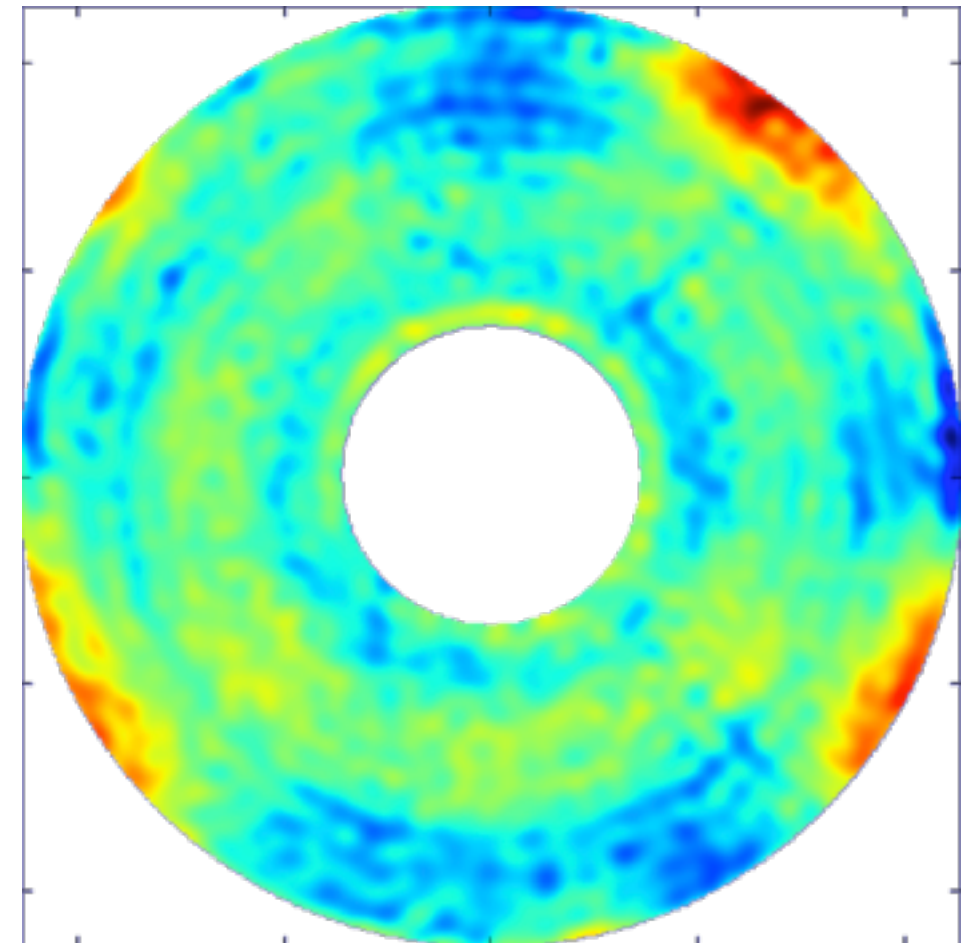
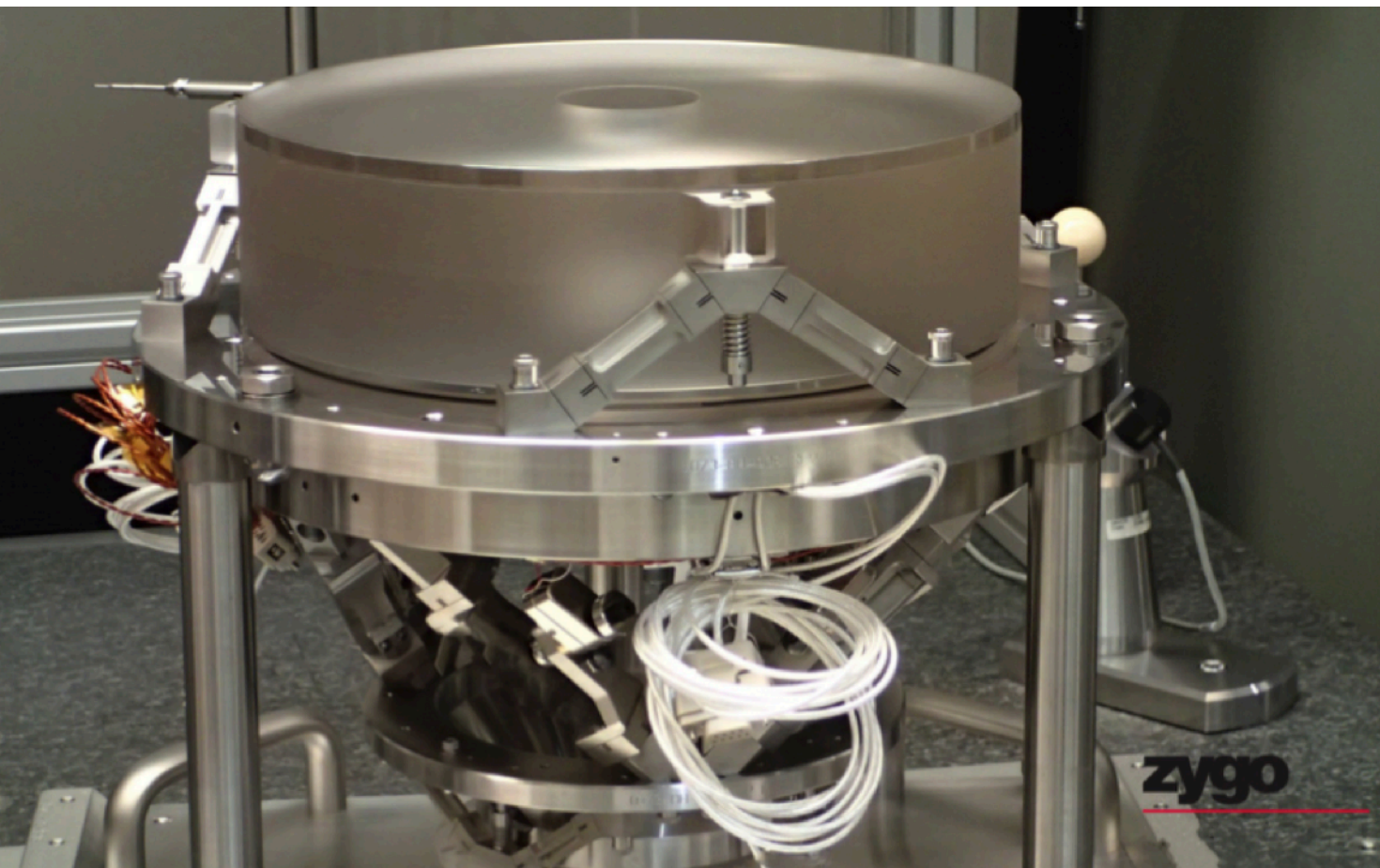


**zygo®**

**Low-order Zernike terms can be aligned out**



# “Non-alignable” aberrations

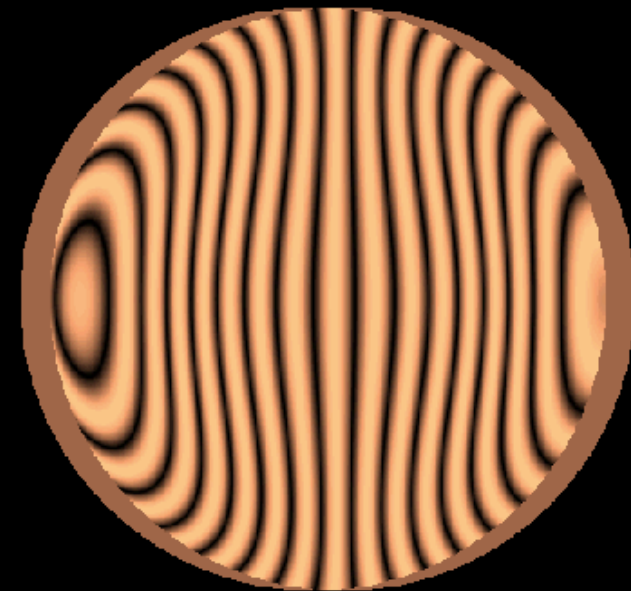
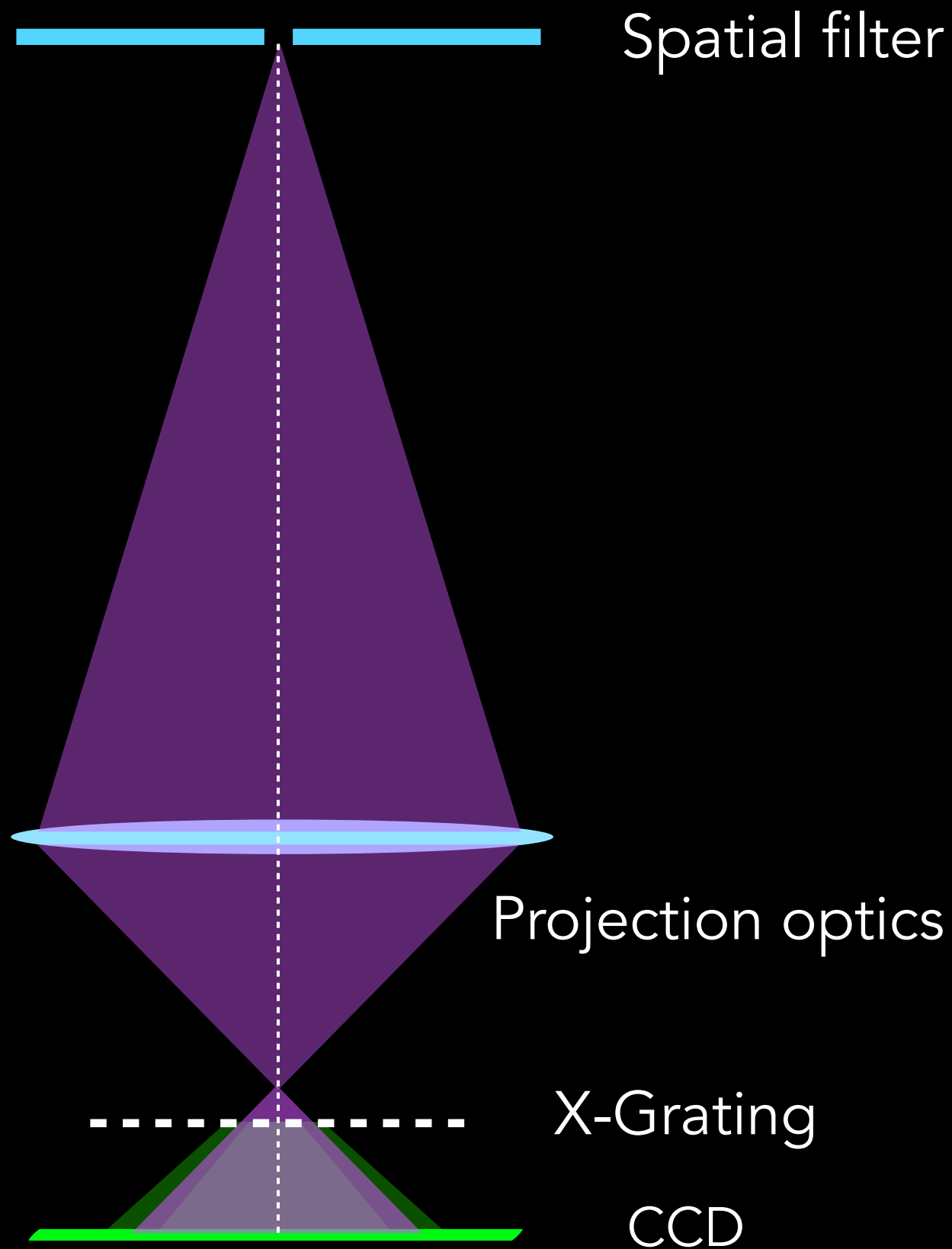


**Total intrinsic rms wavefront: 0.21 nm**

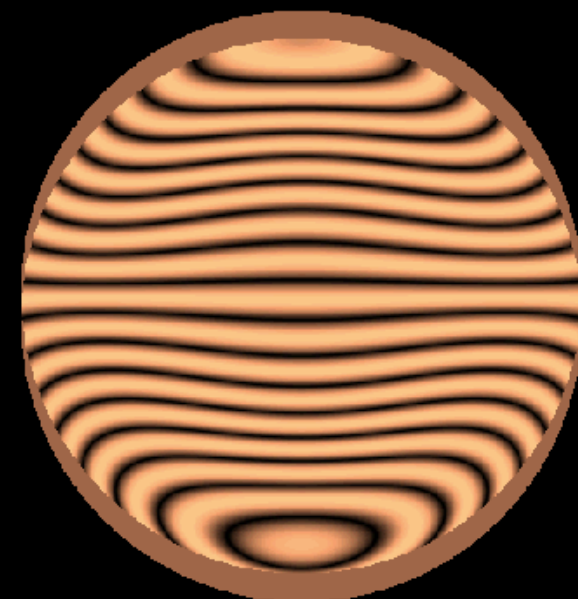
**Figure error: < 0.04 nm**



# Lateral shearing interferometry



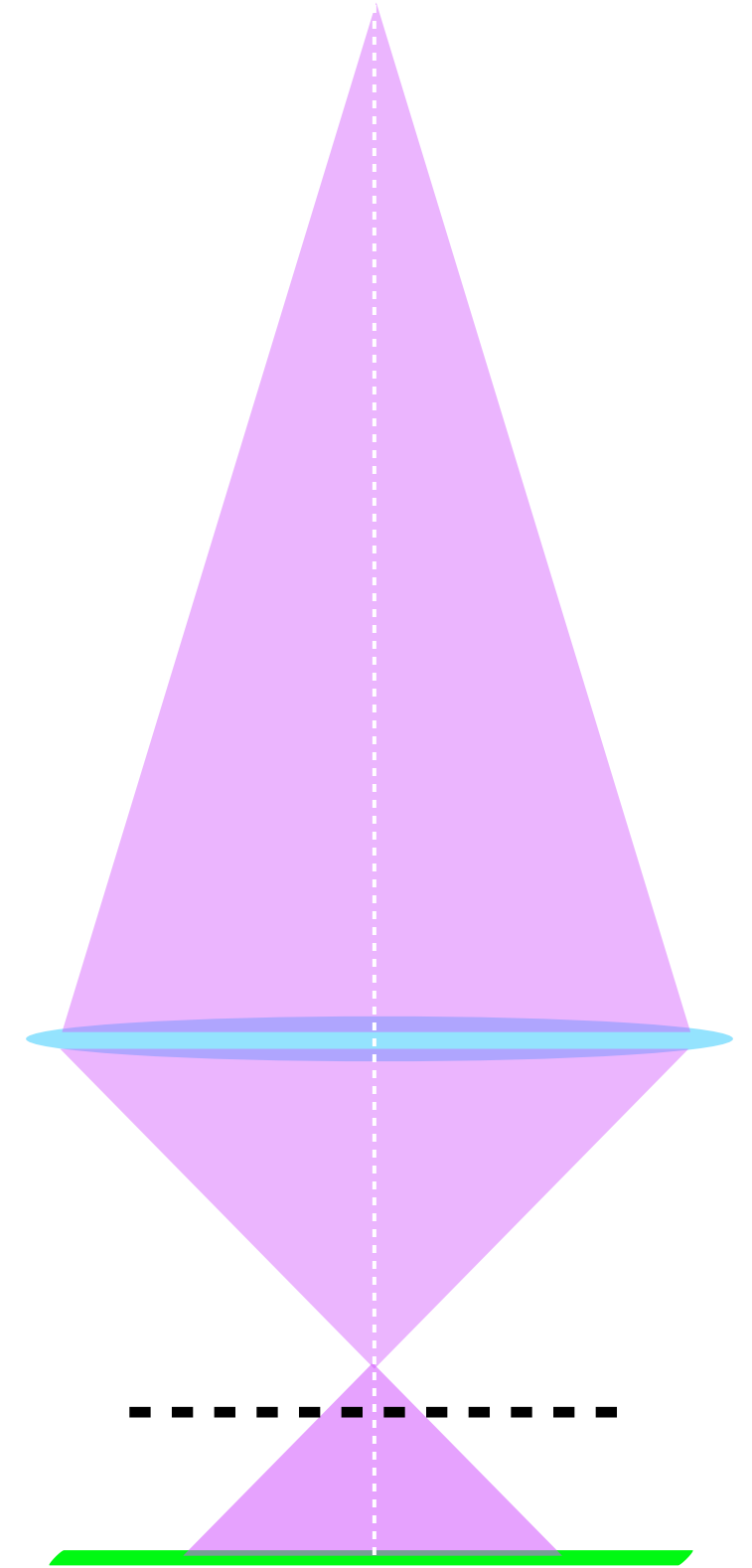
$$\phi_x = w(x + s, y) - w(x, y)$$



$$\phi_y = w(x, y + s) - w(x, y)$$

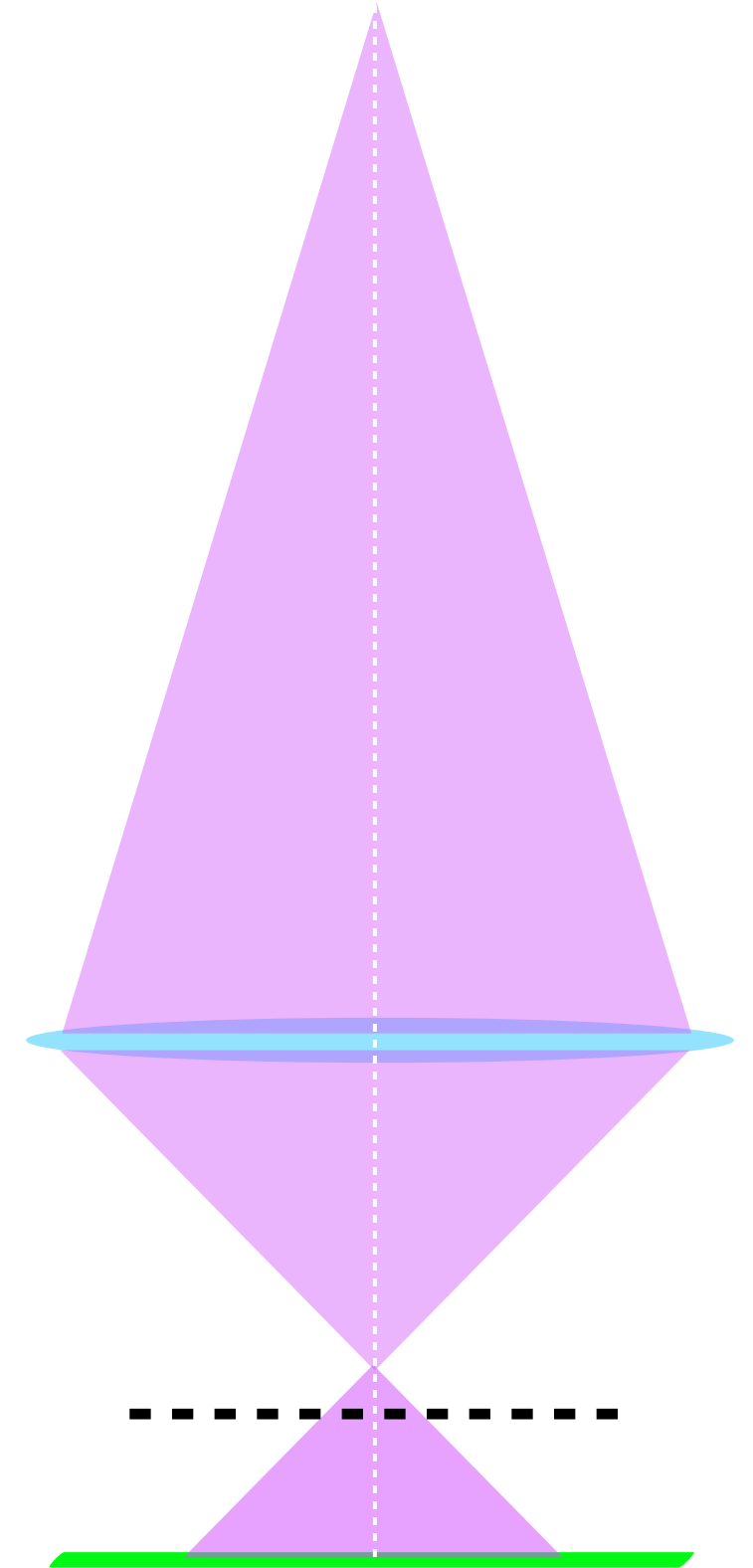
# Lateral shearing interferometry

- Only requires beam quality and coherence over shear distance



# Lateral shearing interferometry

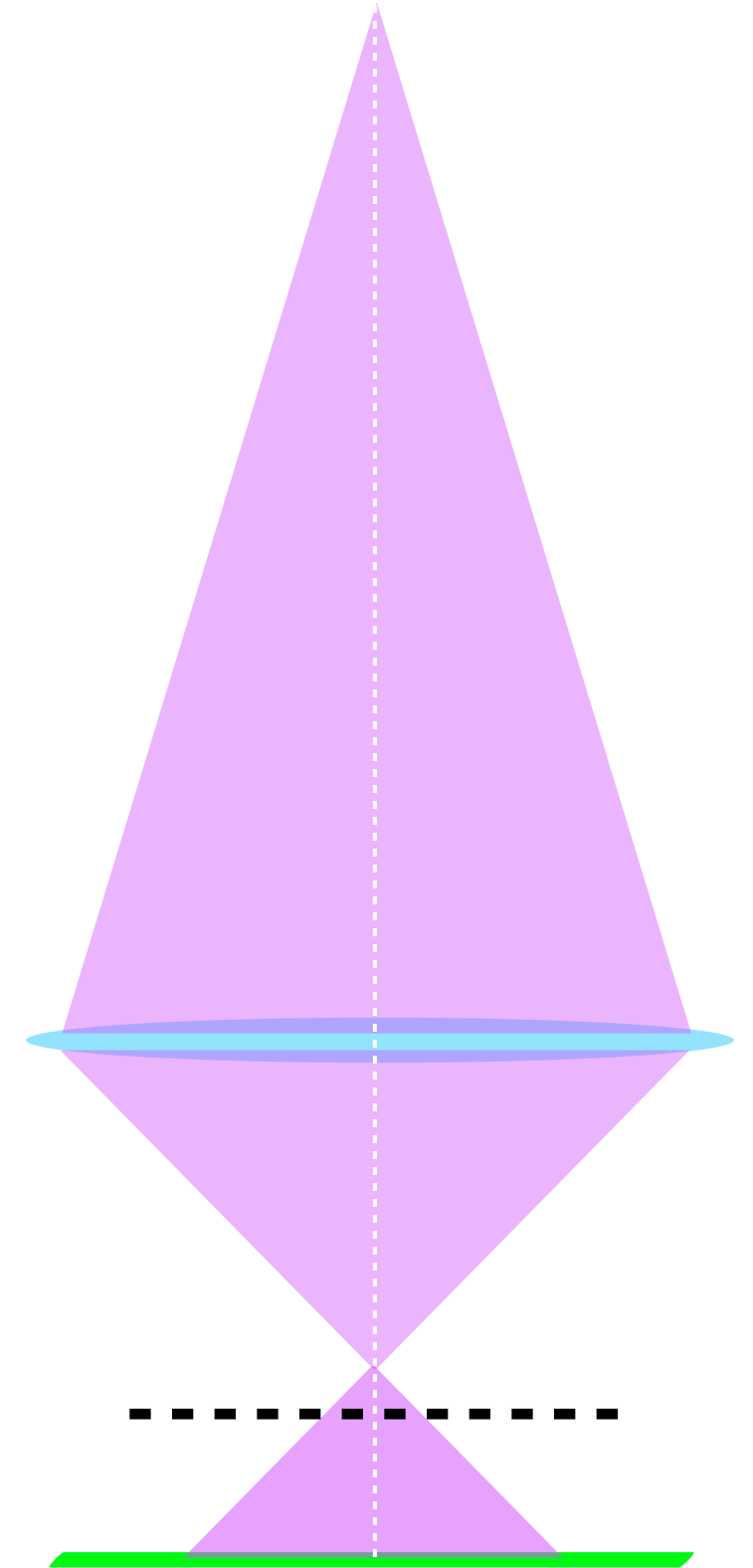
- Only requires beam quality and coherence over shear distance
- Can be incoherently multiplexed





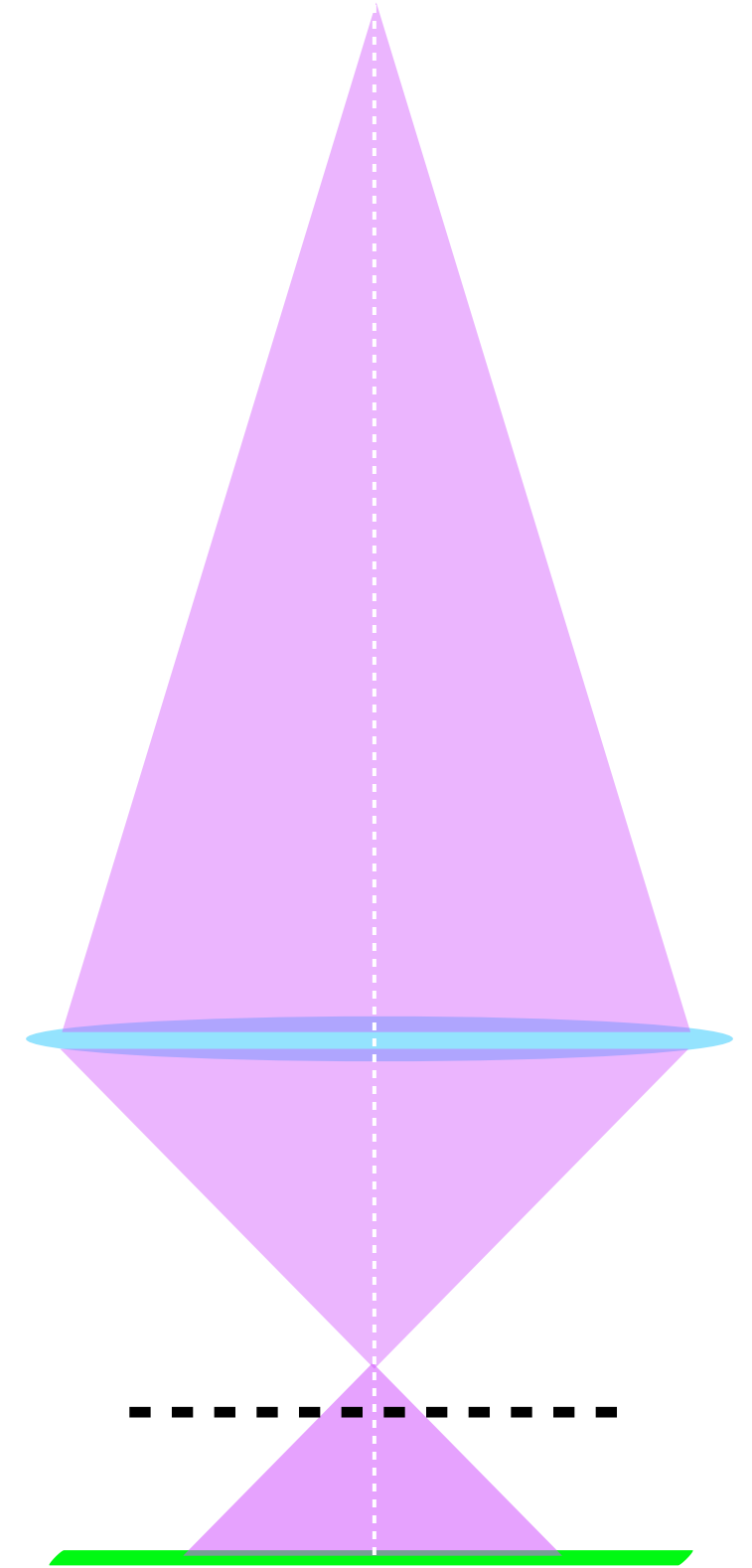
# Lateral shearing interferometry

- Only requires beam quality and coherence over shear distance
- Can be incoherently multiplexed
- Can fill NA with combination of diffraction and illumination



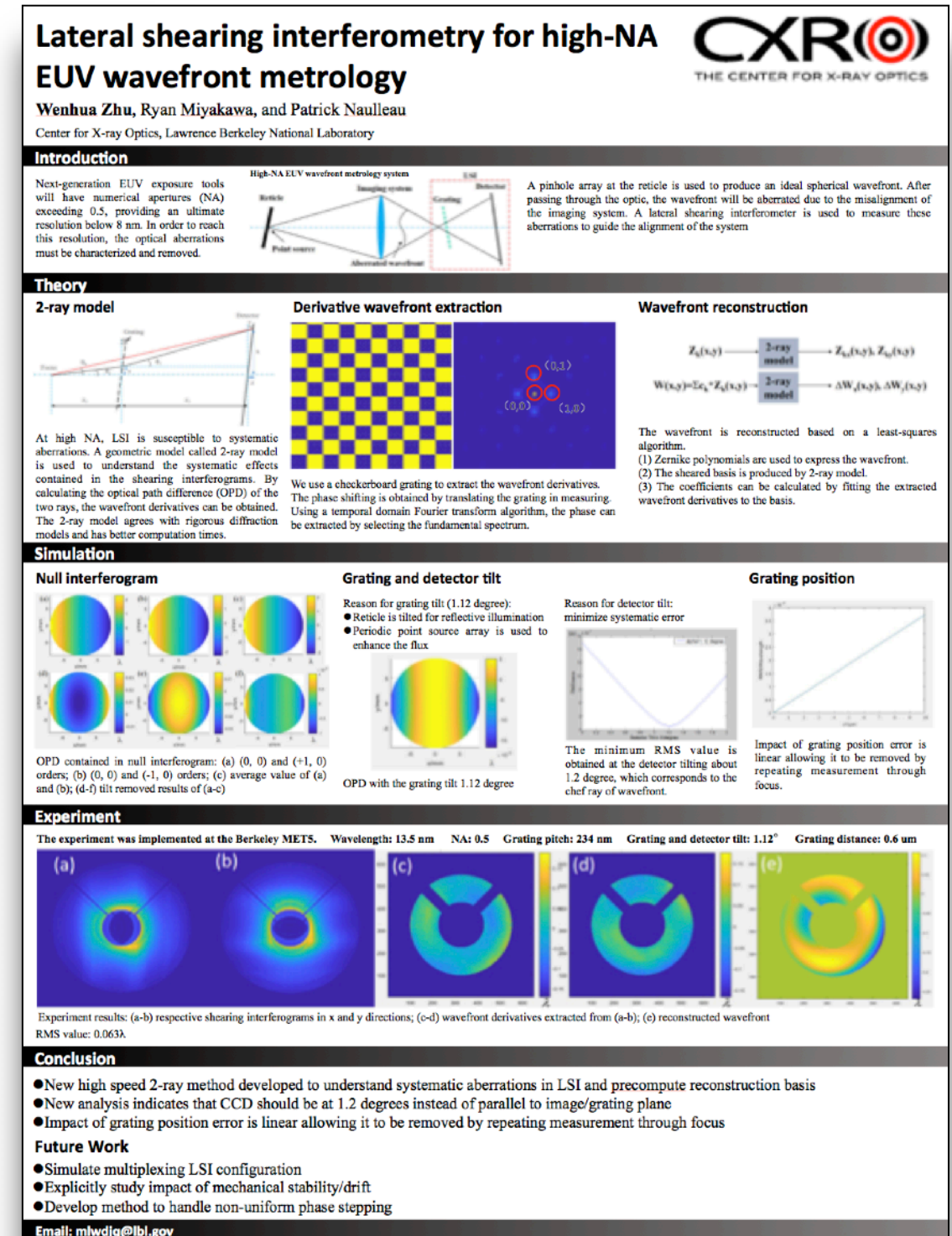
# Lateral shearing interferometry

- Only requires beam quality and coherence over shear distance
- Can be incoherently multiplexed
- Can fill NA with combination of diffraction and illumination
- Adaptable to non-telecentric systems like MET5



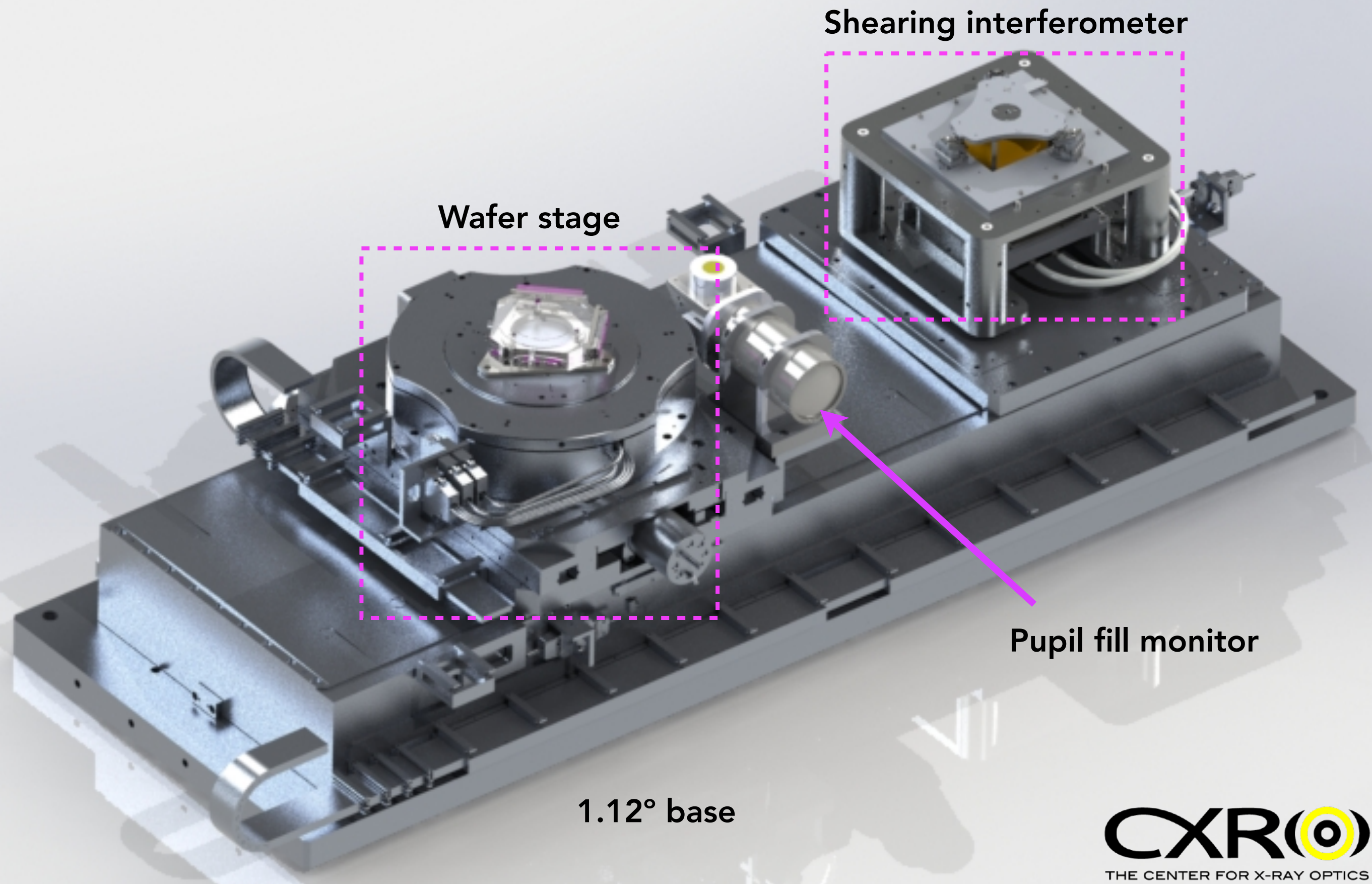
# Lateral shearing interferometry

- For more details on adapting LSI for high NA, see poster by Wenhua Zhu





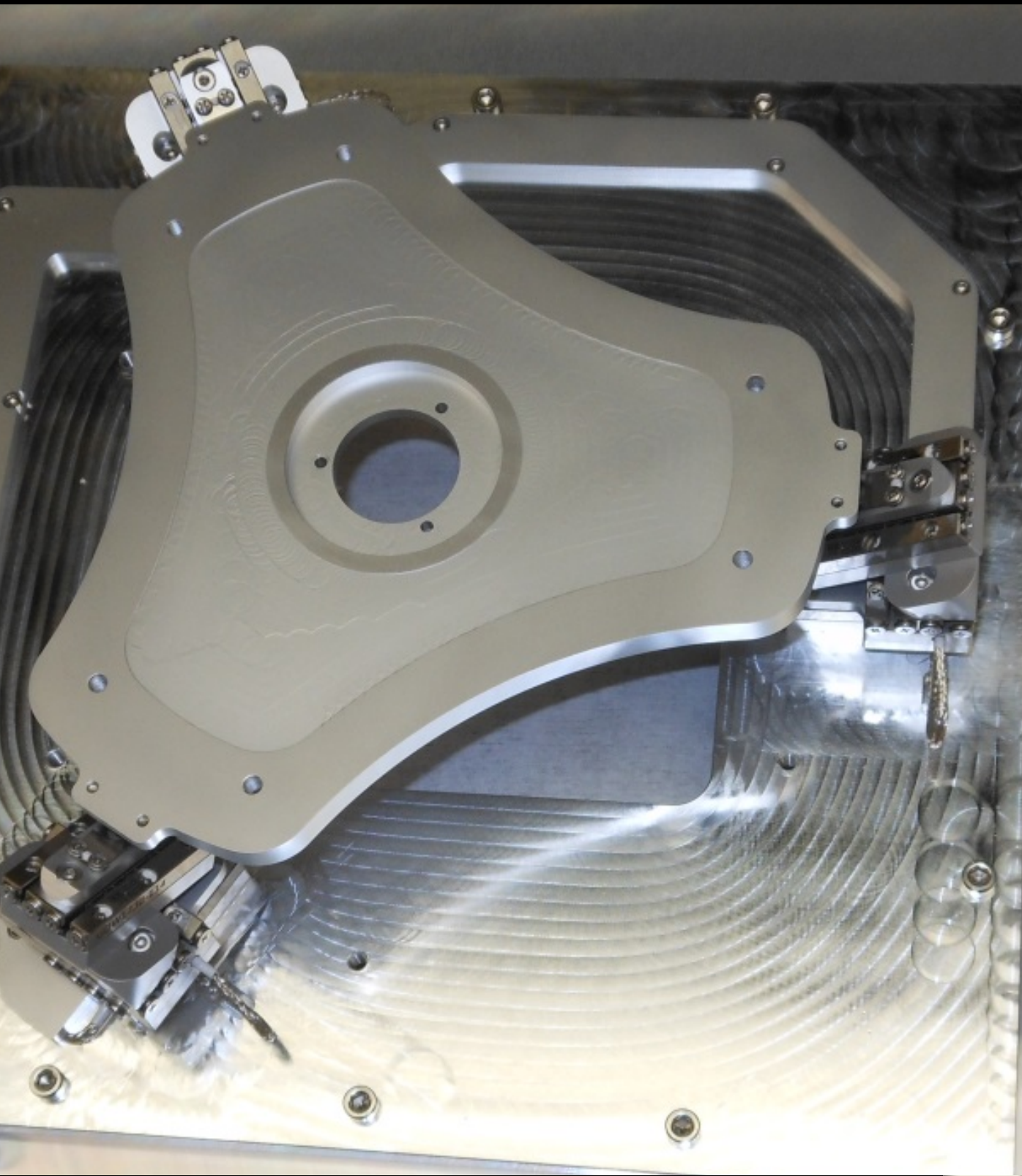
# MET5 Imaging platform



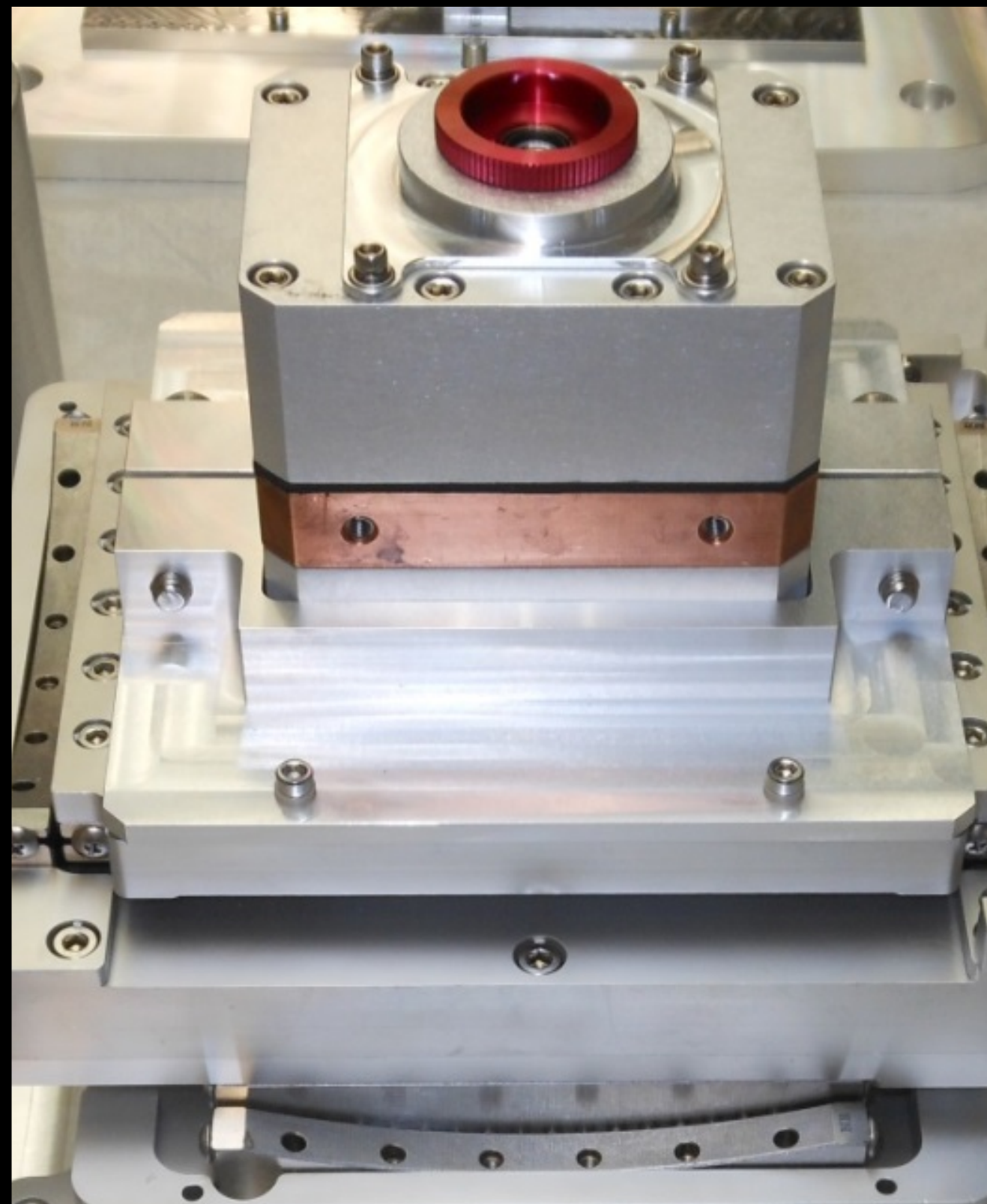


# LSI motion control

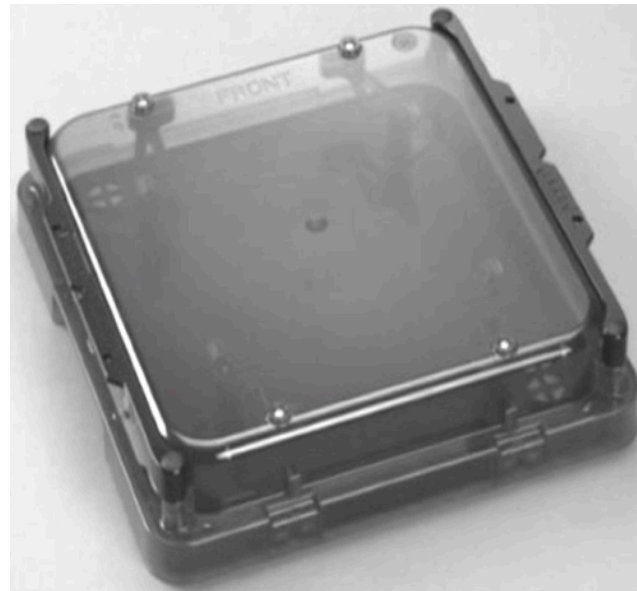
6-axis hexapod



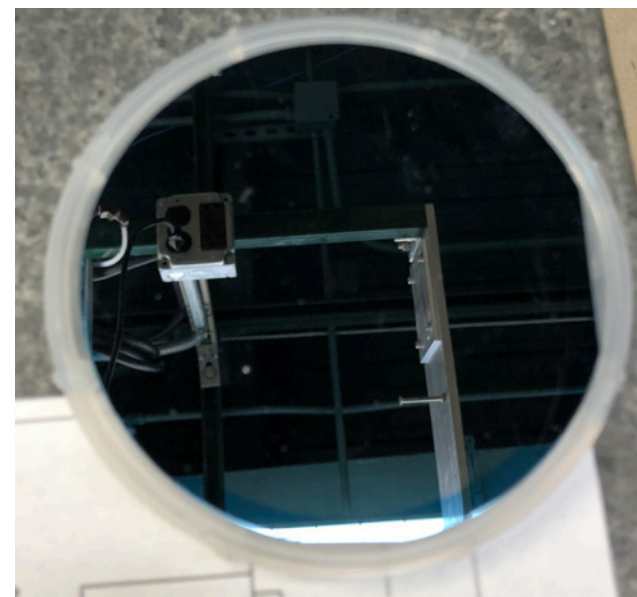
Goniometer



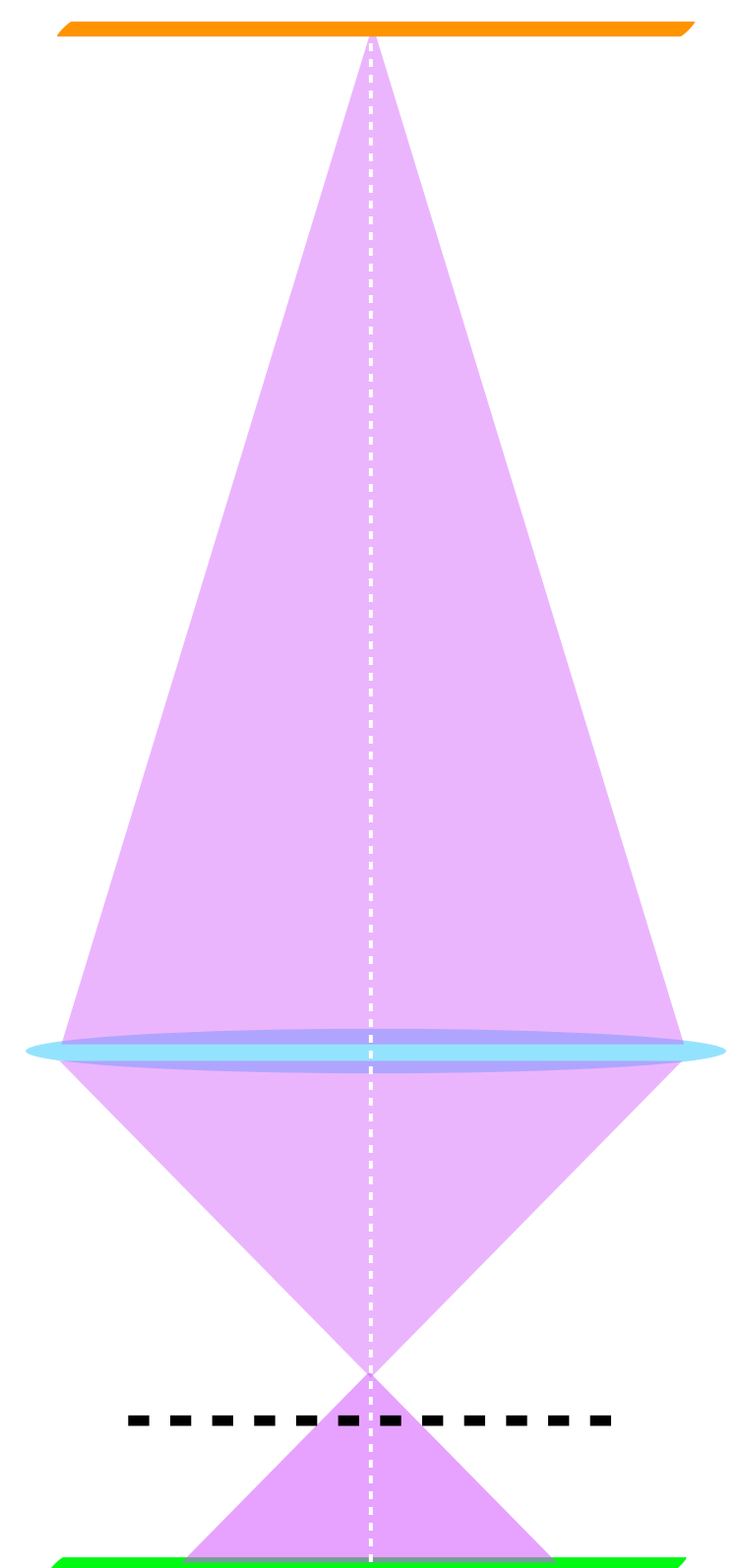
# LSI component integration



**Pinhole array**  
patterned on reticle

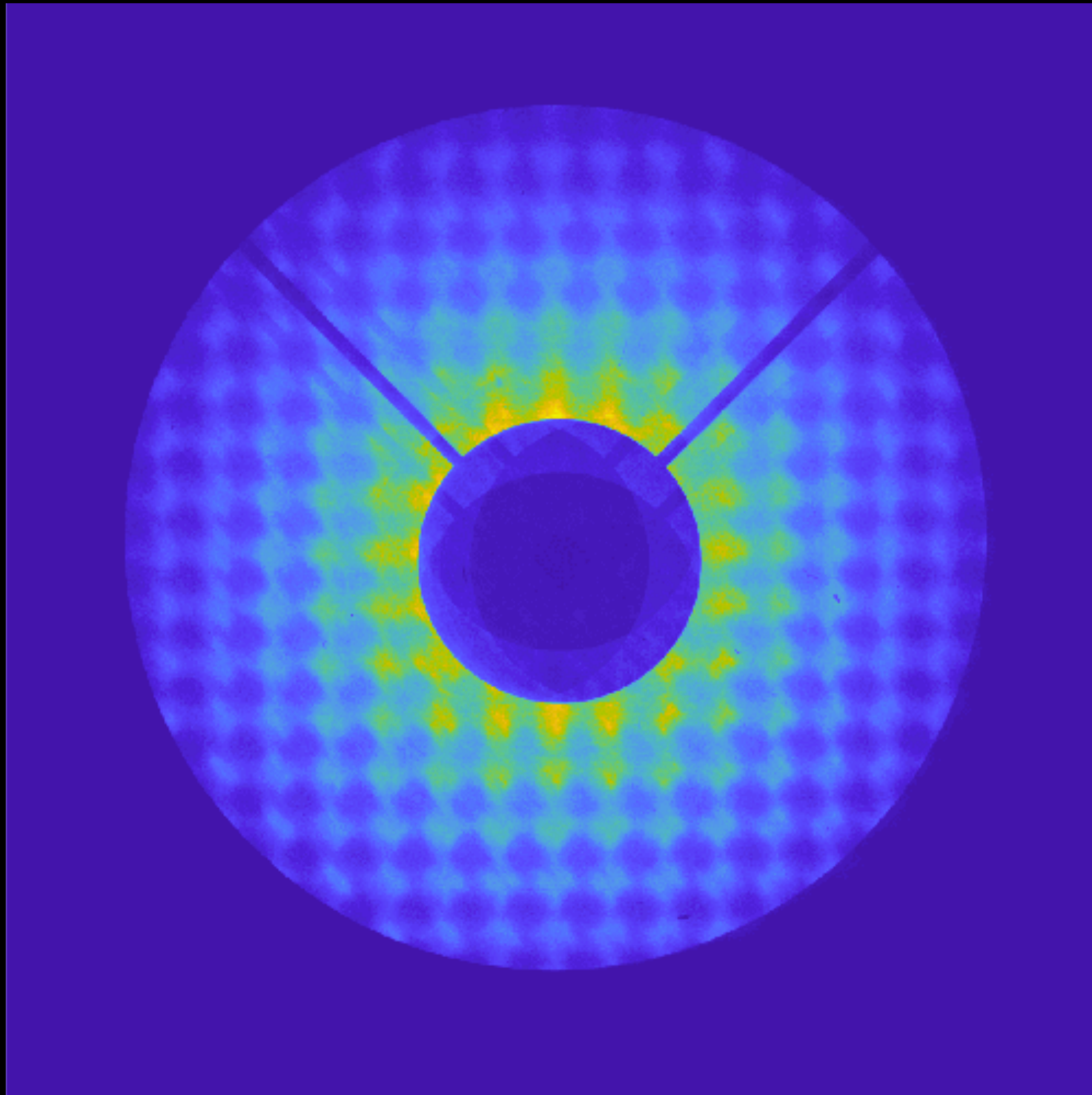


**Grating**  
patterned on wafer



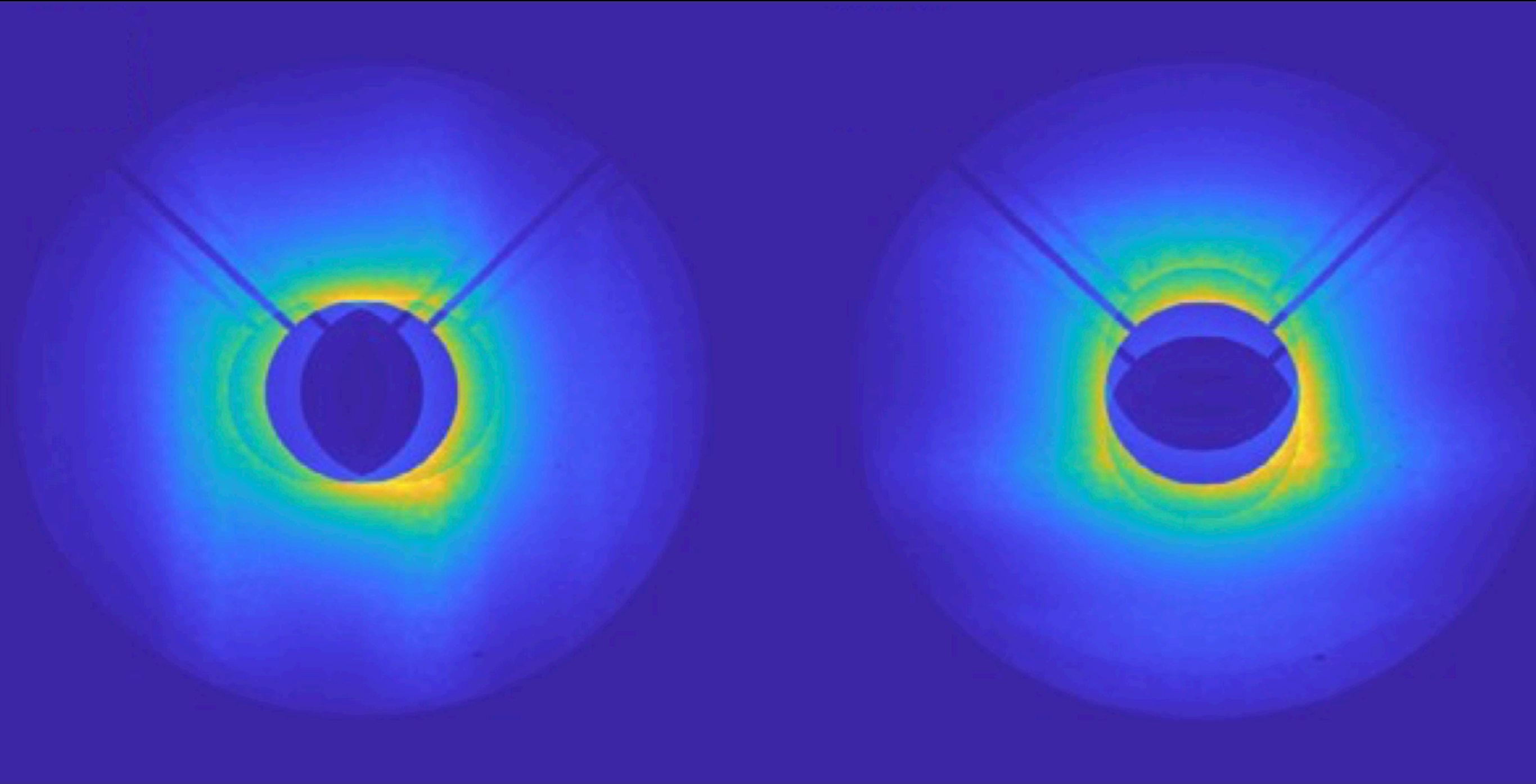


# First interferograms on MET5



$z_1 = 4.0 \text{ um}$  (first Tablot plane)

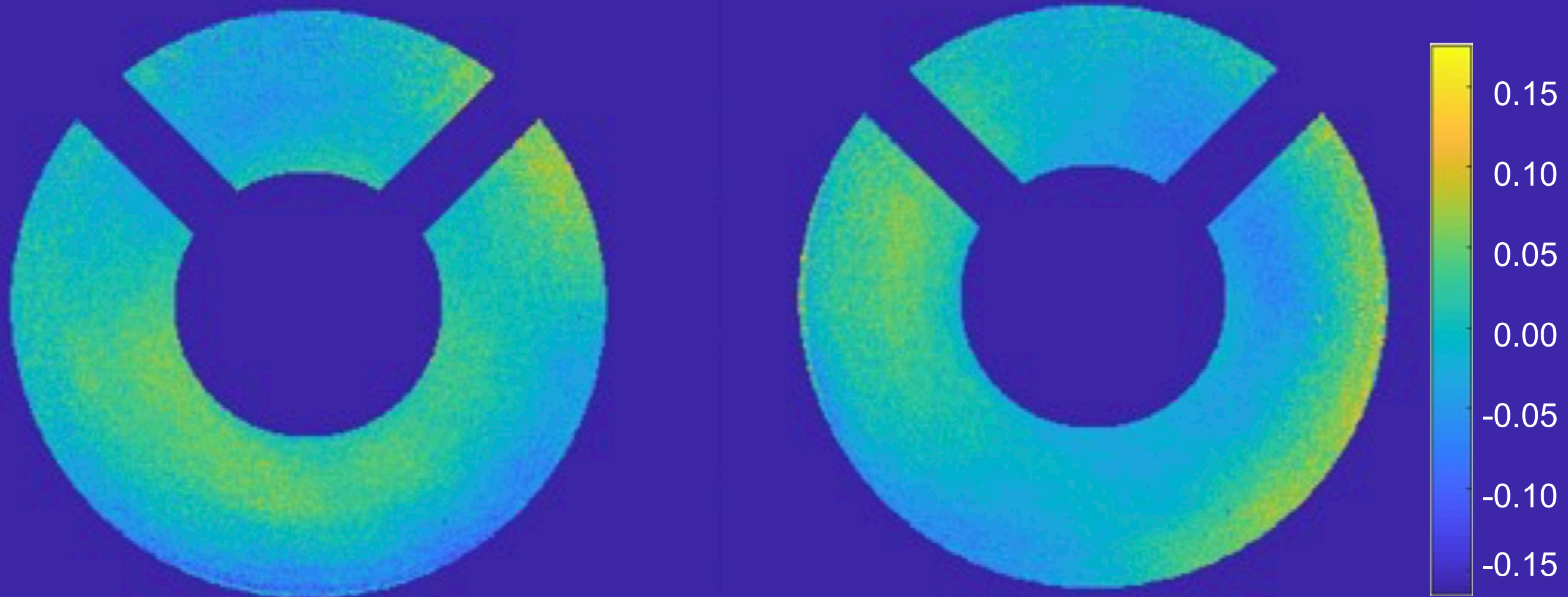
# First interferograms on MET5



$z_1 = 500 \text{ nm}$

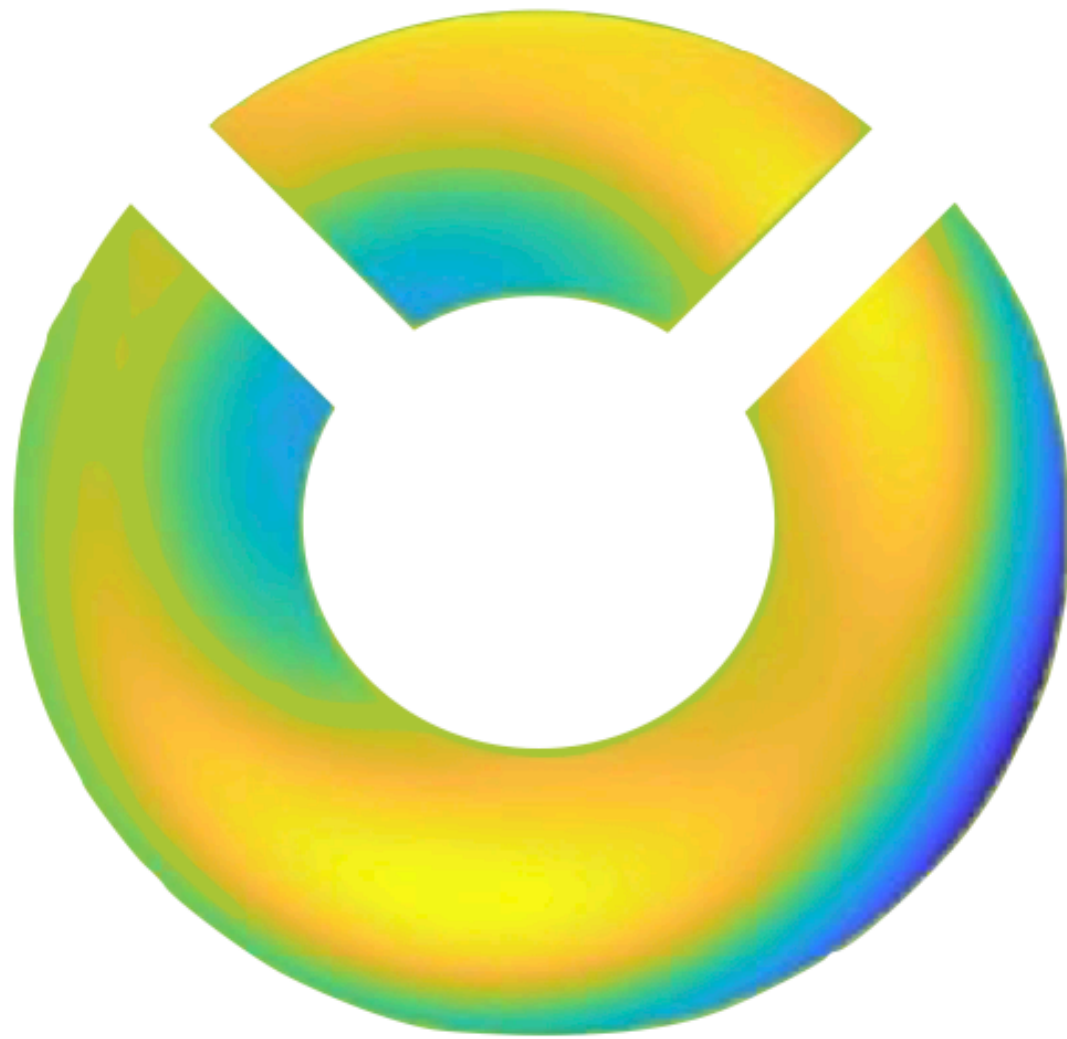


# First interferograms on MET5

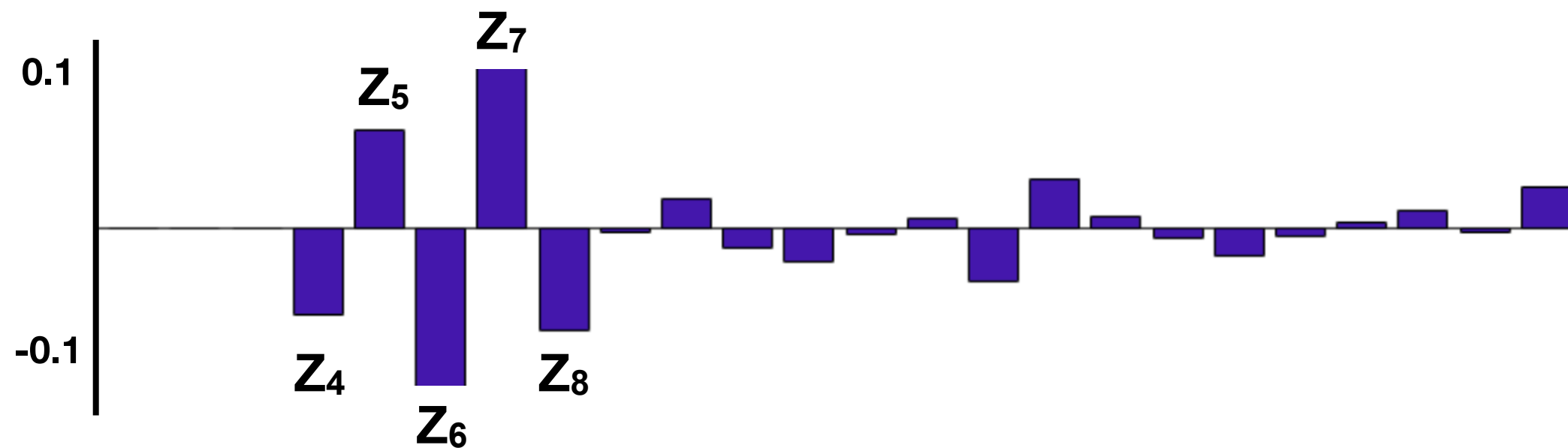


$z_1 = 500 \text{ nm}$

# LSI Wavefront analysis



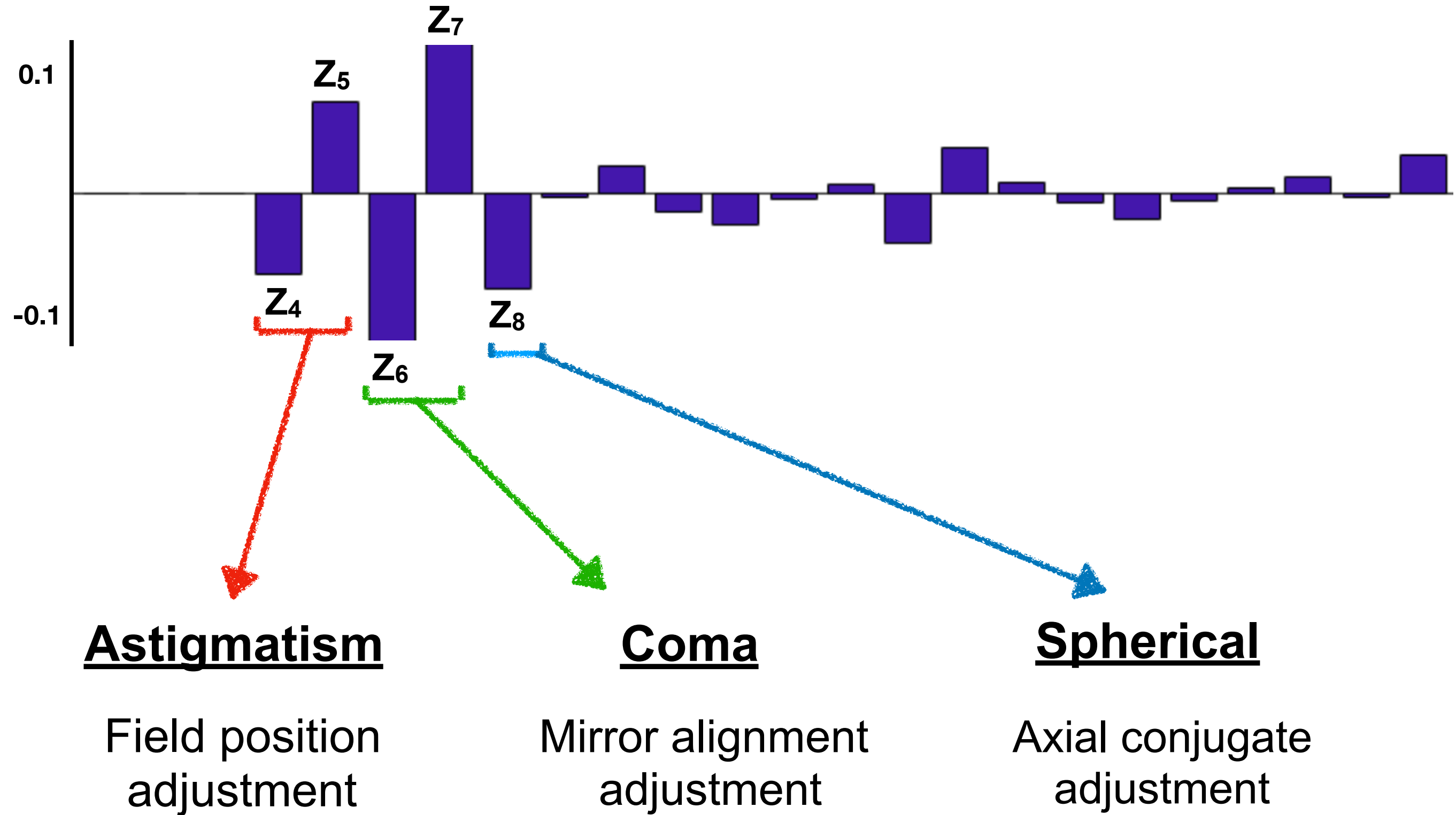
**Total rms wavefront:  
0.89 nm**



**Aberration magnitude by Zernike coefficient (nm p2v)**



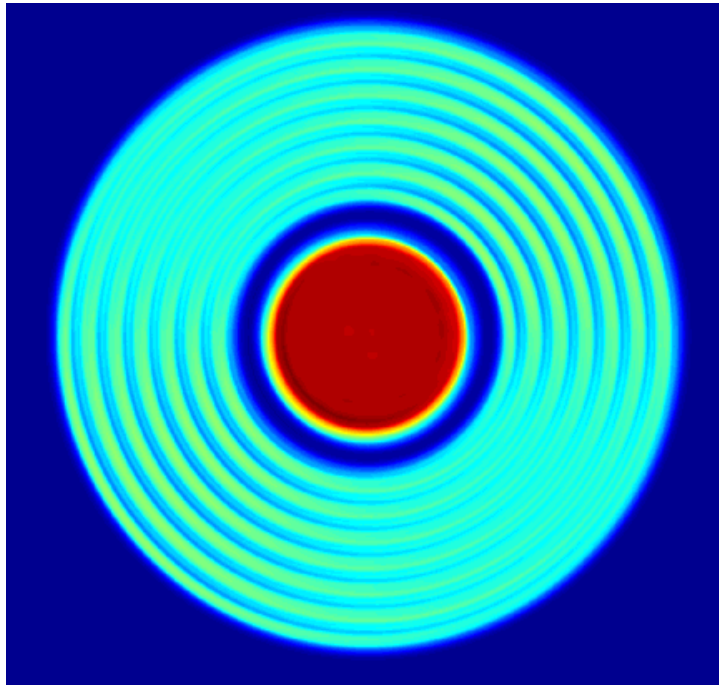
# LSI Wavefront analysis



# Comparison with print results

Compared printing of radial gratings 90 nm from focus

MAST aerial image

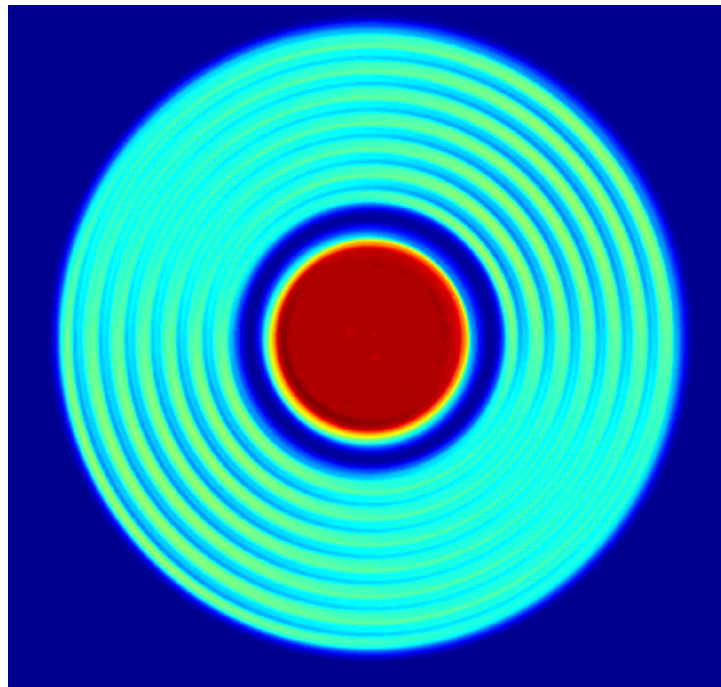




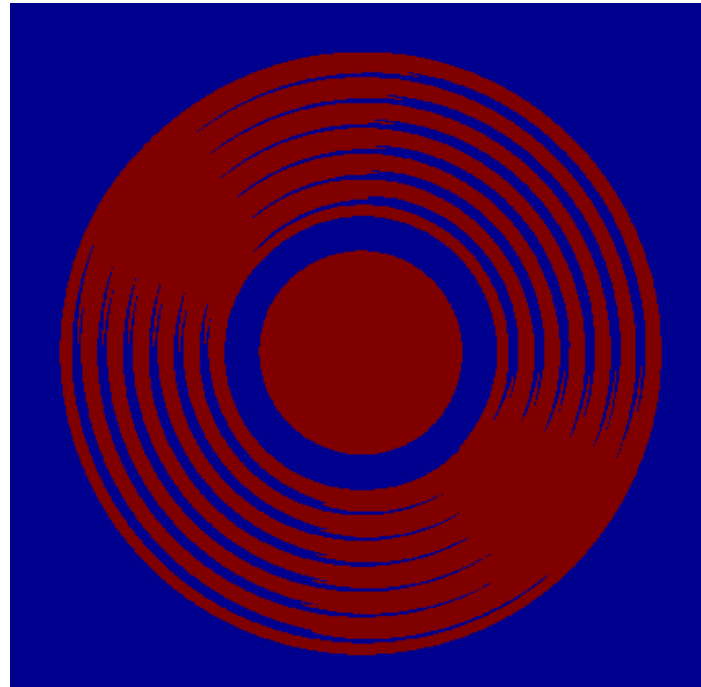
# Comparison with print results

Compared printing of radial gratings 90 nm from focus

**MAST aerial image**



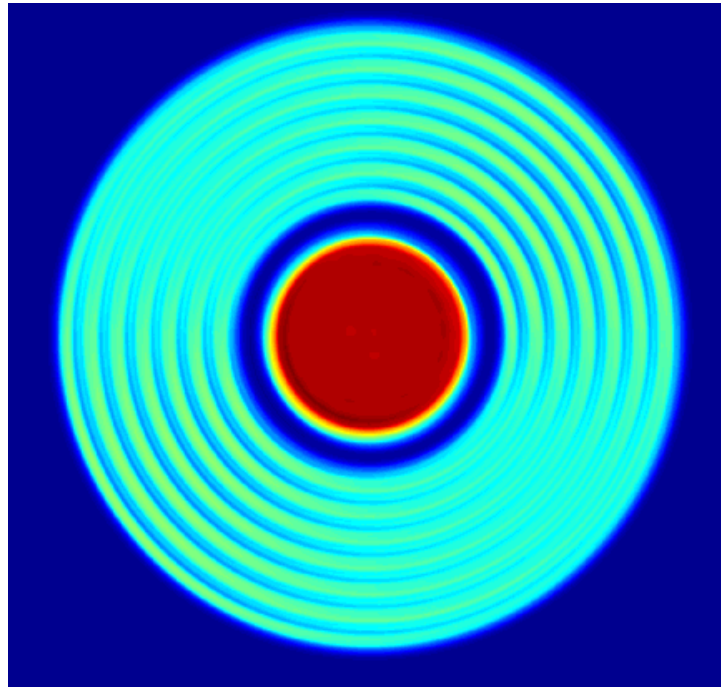
**Thresholded**



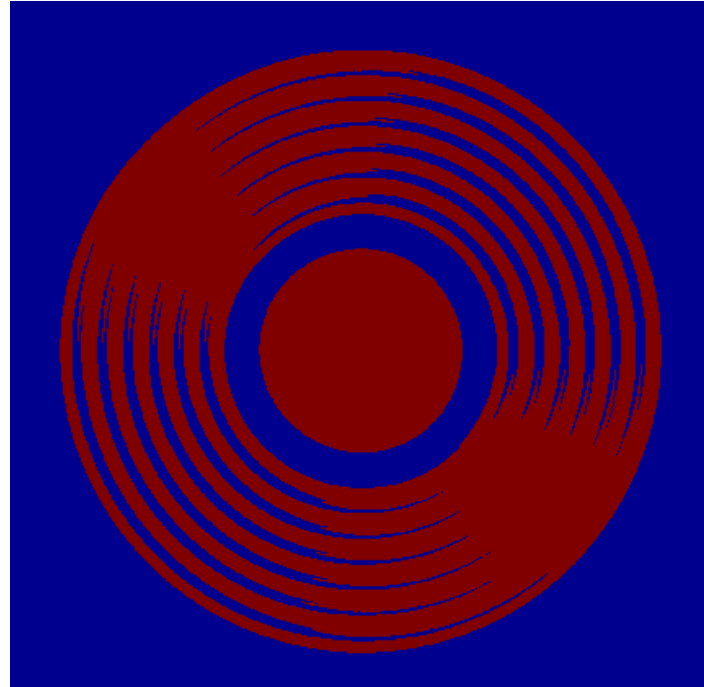
# Comparison with print results

Compared printing of radial gratings 90 nm from focus

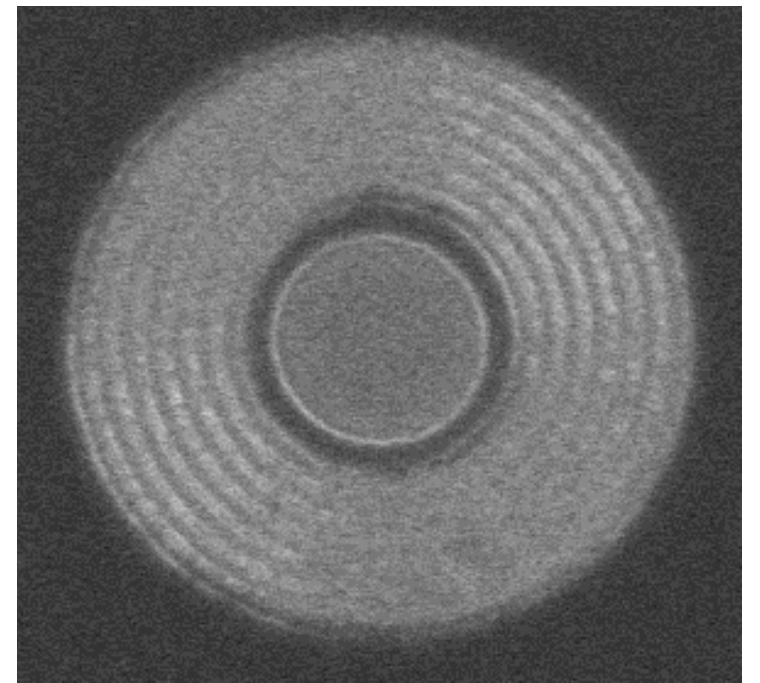
MAST aerial image



Thresholded



Print results



*\* Good agreement between measured aberrations and print results*



# Next up...

